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LETTER REPORT

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT SOURCE AREA DELINEATION AND RISK-BASED CONSERVATIVE SCREEN AND ENVIRONMENTAL PROTECTION AGENCY AREAS OF CONCERN DELINEATION

HUMAN HEALTH RISK ASSESSMENT 903 PAD, MOUND, AND EAST TRENCHES AREAS OPERABLE UNIT NO 2

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

VOLUME 1
(SECTIONS 1-8)

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM
September 27, 1994

NOTICE

All drawings located at the end of the document

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U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
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ENVIRONMENTAL RESTORATION PROGRAM

September 27, 1994

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LIST OF ACRONYMS

Am 241	americium 241
AOC	area of concern
ARAR	applicable or relevant and appropriate regulation
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
COC	chemical of concern
DOE	U S Department of Energy
EPA	U S Environmental Protection Agency
FS	feasibility study
HHRA	human health risk assessment
IHSS	individual hazardous substance site
OU2	Operable Unit No 2
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCOC	potential chemical of concern
Pu 239 240	plutonium 239 240
RBC	risk based concentration
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFETS	Rocky Flats Environmental Technology Site
RfD	reference dose
RFP	Rocky Flats Plant
SF	slope factor
SOP	standard operating procedure
SVE	soil vapor extraction
SVOC	semi volatile organic compound
TCE	trichloroethene
TSS	total suspended solids
U 233 234	uranium 233 234
U 235	uranium 235
U 238	uranium 238
UHSU	upper hydrostratigraphic unit
$UTL_{99/99}$	99 percent upper tolerance limit at the 99 percent upper confidence level
VOC	volatile organic compound

EXECUTIVE SUMMARY

This executive summary provides results of the Colorado Department of Public Health and Environment (CDPHE) Risk Based Conservative Screen for the 903 Pad Mound and East Trenches Area Operable Unit No 2 (OU2) at the Rocky Flats Environmental Technology Site (RFETS) in Golden Colorado The 903 Pad Mound and East Trenches Areas contain 20 Individual Hazardous Substances Sites (IHSSs) where waste materials were formerly stored or deposited The CDPHE Risk Based Conservative Screen was developed to support CDPHE s evaluation of contaminant source areas The source areas in the CDPHE screen will be used to define areas of concern (AOC) for evaluation in the Human Health Risk Assessment (HHRA) portion of the Phase II RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for OU2 The screen is used to support the identification of contaminant source areas low hazard areas that may warrant no further evaluation high hazard areas that may warrant potential early action and those areas which need to be evaluated in the HHRA The CDPHE screen also provides a decision point as to whether a feasibility study (FS) is warranted Finally the CDPHE screen also supports the delineation of AOCs that will be evaluated in the HHRA The HHRA is performed as part of the RCRA Facility Investigation/Remedial Investigation (RFI/RI) conducted pursuant to the U S Department of Energy (DOE) Environmental Restoration Program a Compliance Agreement between DOE the U S Environmental Protection Agency (EPA) and CDPHE and the Federal Facility Agreement and Consent Order (Interagency Agreement) signed in 1991

The CDPHE Conservative Risk Based Screen includes the following six steps

- Step 1 Define potential chemicals of concern (PCOCs) in soil and groundwater
- Step 2 Identify contaminant source areas based on distribution of PCOCs
- Step 3 Calculate a health risk based concentration (RBC) for each PCOC in soil and groundwater

- Step 4 — Calculate the ratio of the maximum concentration of each PCOC to the corresponding RBC sum the ratios for each medium and for each source area

- Step 5 — Apply CDPHE conservative screen decision criteria to the RBC ratio sums for each source area

- Step 6 — Define area(s) of concern (AOC) for the HHRA based on source areas

In Step 1 PCOCs were identified soil and groundwater PCOCs are defined as (a) metals and radionuclides significantly above background levels as determined by statistical tests (Gilbert 1993) and (b) organic target analytes that were detected above analytical detection limits

The chief PCOCs in surface soil were the radionuclides americium 241 (Am 241) and plutonium 239 240 (Pu 239 240) the uranium isotopes U 233 234 U 235 and U 238 chlorinated solvents such as tetrachloroethene (PCE) trichloroethene (TCE) and carbon tetrachloride polycyclic aromatic hydrocarbons (PAHs) and numerous metals (some of the metal PCOCs may be naturally occurring even though statistical evaluation identified them as being above background levels) The chief PCOCs in groundwater were chlorinated solvents such as PCE TCE and carbon tetrachloride nitrates Am 241 and Pu 239 240 and most metals Elevated metals concentrations in unfiltered groundwater samples are probably not due to contamination but rather due to high total suspended solids resulting from difficulty in sampling wells with low yields to geochemical characteristics of the groundwater or other factors

In Step 2 PCOC concentrations above background arithmetic mean plus two standard deviations (inorganics) or detection limits (organics) were plotted on maps and contaminant source areas were identified based on the distribution of PCOCs Source areas were defined as areas containing concentrations or radioactivities of inorganic PCOCs above the background arithmetic mean plus two standard deviations or areas where organic PCOCs were detected Source areas include contaminated soil and associated groundwater

contaminant plumes if any Five source areas were identified in OU2 These are illustrated in Figure 3 1 and listed below

- 903 Pad Source Area. This source area includes IHSSs 109 112 140 155 and 185 at the 903 Pad area groundwater contaminant plumes flowing northeast and southeast of the 903 Pad area and IHSSs 111 6 111 7 111 8 (Trenches T 9 T 10 and T 11) Trenches T 12 and T 13 and portions of Trench T 5 (IHSS 111 2) which are located within the area bounded by the northeast extension of the groundwater contaminant plume

- Mound Source Area. This source area includes IHSSs 108 113 153 and 154 in the Mound area and associated groundwater contaminant plume that flows north and east of the source area

- Northeast Trenches Source Area This source area includes Trenches T 3 and T 4 and an associated groundwater contaminant plume extending north of the trenches

- Southeast Trenches Source Area This source area includes a portion of Trench T 5 (IHSS 111 2) and Trenches T 6 through T 8 (IHSSs 111 3 through 111 5) No groundwater is present in this area

- East of IHSSs Source Area. No IHSSs are located in this area However this area includes groundwater east of the previously described source areas and surface and subsurface soil within this area

In Step 3 RBCs were developed for each PCOC Chemical specific RBCs are presented in the Final Rocky Flats Programmatic Risk Based Preliminary Remediation Goals (DOE 1994b) The RBCs used in this conservative screen were based on a residential scenario for exposure to soil and groundwater

In Step 4 maximum detected concentrations or radioactivities of PCOCs in each medium were compared to RBCs The following ratio was calculated for each PCOC in each source area

$$Ratio = \frac{Maximum\ detected\ concentration\ or\ activity\ of\ PCOC}{RBC\ for\ PCOC}$$

In each source area PCOC specific ratios were summed to yield a ratio sum for soil and groundwater Ratio sums above 1 indicate that cumulative effects of PCOCs at maximum detected concentrations exceed a conservative risk based screening level and that the source area warrants further evaluation

A summary of the ratio sums by source area is shown in Table ES 1 All of the source areas in OU2 have RBC ratio sums greater than 1 for residential exposure to soil (0 to 12 feet below ground surface) All of the source areas that include groundwater have RBC ratio sums greater than 100 for groundwater assuming residential use

In Step 5 the following decision criteria were used to classify the source areas

- If the ratio sum $\geq$ 100 indicating a potential health hazard assuming long term exposure to maximum detected concentrations a voluntary corrective action (early action) or a baseline HHRA will be conducted

- If 1 $<$ ratio sum $<$ 100 a baseline HHRA must be conducted

- If the ratio sum $\leq$ 1 indicating a low hazard source area no further action may be required pending evaluation of Applicable or Relevant and Appropriate Requirements (ARARs) and incremental risk from dermal exposure

None of the source areas had ratio sums less than 1 assuming residential exposure to maximum contaminant concentrations in all media Therefore all source areas will be evaluated further in a baseline HHRA or as candidates for early action

In Step 6 AOCs for OU2 were identified for the HHRA AOCs are defined as one or several source areas grouped spatially in close proximity In the HHRA for OU2 the 903 Pad Mound Northeast Trenches and Southeast Trenches source areas were grouped as AOC No 1 since they are in close proximity the contamination in those four source areas is similar and the 903 Pad Mound and Northeast Trenches areas are hydrogeologically connected East of IHSSs area is designated as AOC No 2

TABLE ES 1
ROCKY FLATS OU2
SUMMARY OF TOTAL RATIO SUMS BY SOURCE AREA

	Medium	Carcinogenic Ratio	Noncarcinogenic Ratio
903 Pad	Soil to 12 feet	3460 00	4 50
	Groundwater	334000 00	1280 000
Total Ratio [1]		337460 00	1284 500
Mound	Soil to 12 feet	81 10	0 31
	Groundwater	41500 00	83 70
Total Ratio [1]		41581 10	84 01
Northeast Trenches	Soil to 12 feet	1390 00	7 34
	Groundwater	70900 00	363 00
Total Ratio [1]		72290 00	370 34
Southeast Trenches[2]	Soil to 12 feet	64 30	0 40
East of IHSSs	Soil to 12 feet	95 40	0 34
	Groundwater	671 00	33 80
Total Ratio [1]		766 40	34 14

[1] Total Carcinogenic Ratio > 1 equivalent to > 10^{-6} cancer risk level
Total Carcinogenic Ratio > 100 equivalent to > 10^{-4} cancer risk level
Total Noncarcinogenic Ratio > 1 equivalent to Hazard Index > 1
(All assuming long term residential exposure to maximum detected concentrations)
[2] No groundwater present in this area based on data from RFI/RI report

1 0
INTRODUCTION

The purpose of this report is to document the results of the Colorado Department of Public Health and Environment (CDPHE) Risk Based Conservative Screen for Operable Unit No 2 (OU2) at the Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) in Golden Colorado OU2 is comprised of the 903 Pad Mound and East Trenches Areas The 903 Pad Mound and East Trenches areas contain 20 Individual Hazardous Substances Sites (IHSSs) where waste materials were formerly stored or deposited The IHSS locations are shown on Figure 1 1 The CDPHE Risk Based Conservative Screen was used to support the identification and CDPHE s evaluation of contaminant source areas low hazard areas that may warrant no further evaluation high hazard areas that may warrant potential early action and those areas which need to be evaluated in the HHRA The CDPHE screen also provides a decision point as to whether a feasibility study (FS) is warranted The CDPHE screen also supports the identification of the larger areas of concern (AOCs) that will be evaluated in the baseline Human Health Risk Assessment (HHRA) portion of the Phase II RCRA Facility Investigation/Remedial Investigation (RFI/RI) report for OU2 An AOC may be comprised of one source area or of several source areas that can be grouped based on close proximity In the RFI/RI report a baseline HHRA will be conducted for each AOC

Guidance for data aggregation for risk assessment and for the risk based screen was provided in a memorandum from DOE (1994a) and in documents prepared jointly by CDPHE U S Environmental Protection Agency (EPA) and DOE (CDPHE/EPA/DOE 1994) The risk based screen compares maximum detected concentrations of potential contaminants in each source area to health risk based concentrations (RBCs) for chemicals in soil or groundwater If the sum of the ratios is less than 1 the source area is a candidate for no further action If the ratio sum exceeds 1 the source area is subject to further evaluation either in a baseline HHRA or as a candidate for early action Therefore the CDPHE Conservative Risk Based Screen can be used to identify no further action source areas potential early action source areas and source areas that can be combined into AOCs for evaluation in the baseline HHRA

The CDPHE Conservative Risk Based Screen does not replace the selection of chemicals of concern exposure pathway analysis exposure assessment toxicity assessment risk characterization and uncertainties analysis that are required in an HHRA and are used to support risk management decisions The relationship of the HHRA to the CDPHE screen is illustrated in Figure 1 2

The process used to conduct the CDPHE Conservative Risk Based Screen is illustrated in Figure 1 3 The steps in the screen are listed below

Step 1 Define Potential Chemicals of Concern (PCOCs) PCOCs are defined as (a) metals and radionuclides significantly above background levels based on statistical evaluation (Gilbert 1993) and (b) organic target analytes detected above reporting limits in soil or groundwater samples in OU2 The background determination was made on the basis of statistical comparison of OU2 data to background data

Step 2 Identify Source Areas Contaminant source areas are defined as areas containing organic PCOCs above reporting limits and/or inorganic PCOCs at concentrations (or radioactivities) above the arithmetic mean plus two standard deviations of the background data

Step 3 Calculate Risk Based Concentrations RBCs are calculated for each PCOC RBCs are health protective chemical concentrations in soil and groundwater calculated using conservative assumptions regarding exposure toxicity and acceptable risk The RBCs used in the CDPHE risk based screen are presented in the Final Rocky Flats Programmatic Risk Based Preliminary Remediation Goals (DOE 1994b) RBCs for soil and groundwater are calculated assuming residential exposure

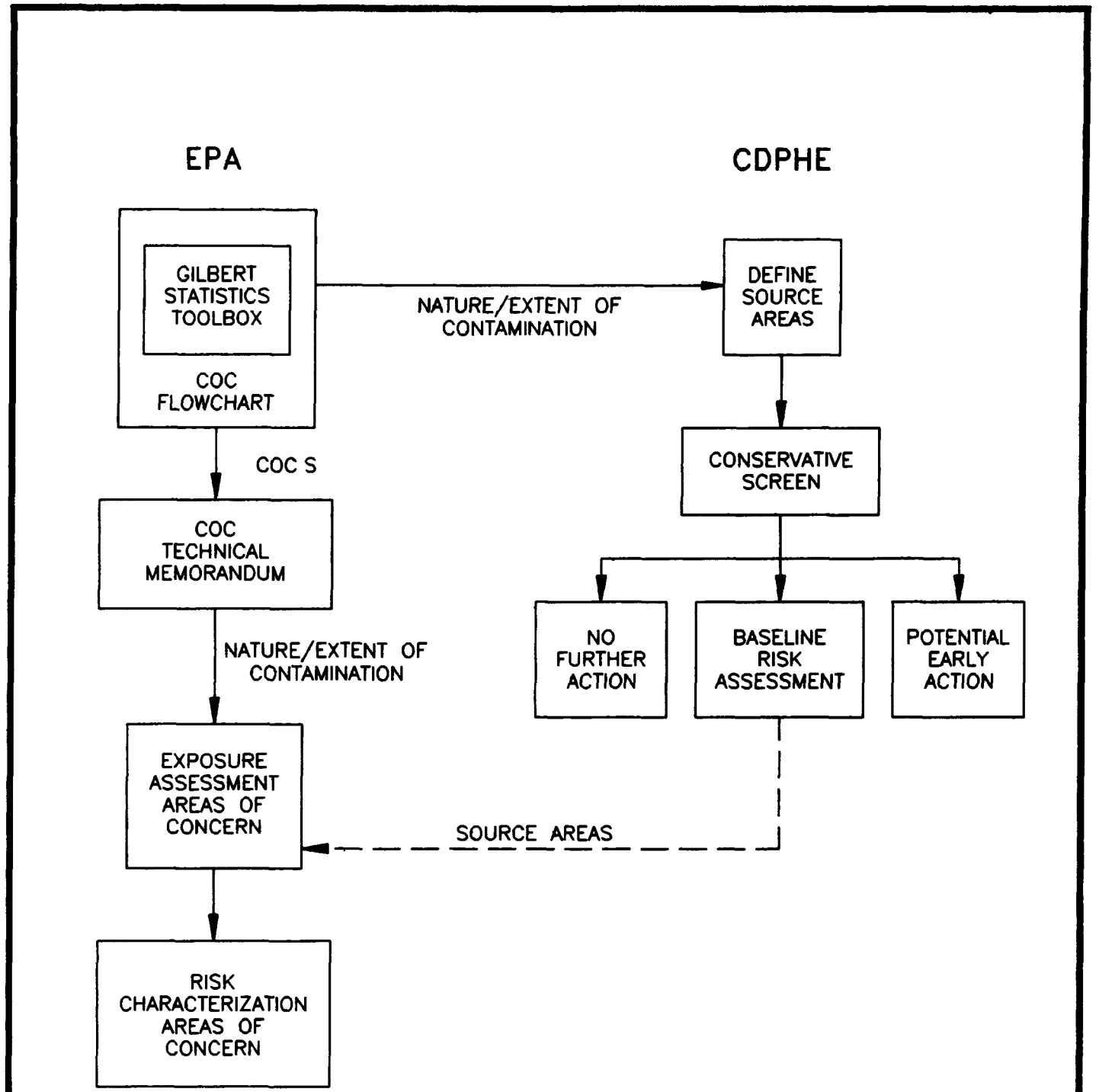
Step 4 Calculate RBC Ratio Sums for Each Source Area The ratio of the maximum detected concentration or radioactivity to the corresponding RBC is calculated for each organic PCOC and for each inorganic PCOC that occurs in the source area at a concentration or radioactivity above the background mean plus two standard deviations Maximum detected concentrations or radioactivities in soil are identified from samples collected to a depth of 12 feet which is the depth

recommended for use by CDPHE The chemical specific and radionuclide specific ratios are then summed for each medium resulting in a ratio sum for the medium (soil and groundwater) Ratio sums for soil and groundwater (if present) are also added to yield a total ratio sum for residential exposure If any ratio or ratio sum exceeds 1 the source area warrants further evaluation

Step 5 Apply CDPHE Conservative Risk Based Screen Decision Criteria The ratio sums determined in Step 4 are used to designate source areas as candidates for no further action or as candidates for further evaluation in the HHRA or possible early action For source areas with ratio sums less than 1 DOE may pursue a no further action alternative Source areas with ratio sums between 1 and 100 will be evaluated in the baseline HHRA For source areas with ratio sums above 100 DOE may pursue a voluntary early action alternative or evaluate the source area further in the baseline HHRA

Step 6 Define AOCs for the HHRA As stated earlier an AOC is a source area or group of source areas in close proximity A baseline HHRA will be conducted for each AOC AOC delineation is reviewed and approved by EPA The baseline HHRA will assess exposure to chemicals of concern (COCs) (a subset of PCOCs) that are identified following EPA and CDPHE approved procedures (The selection of COCs for the HHRA are presented in the Draft Final Technical Memorandum No 9 Chemicals of Concern for OU2 [DOE 1994c])

The following sections of this report describe the application and results of each step of the CDPHE screen



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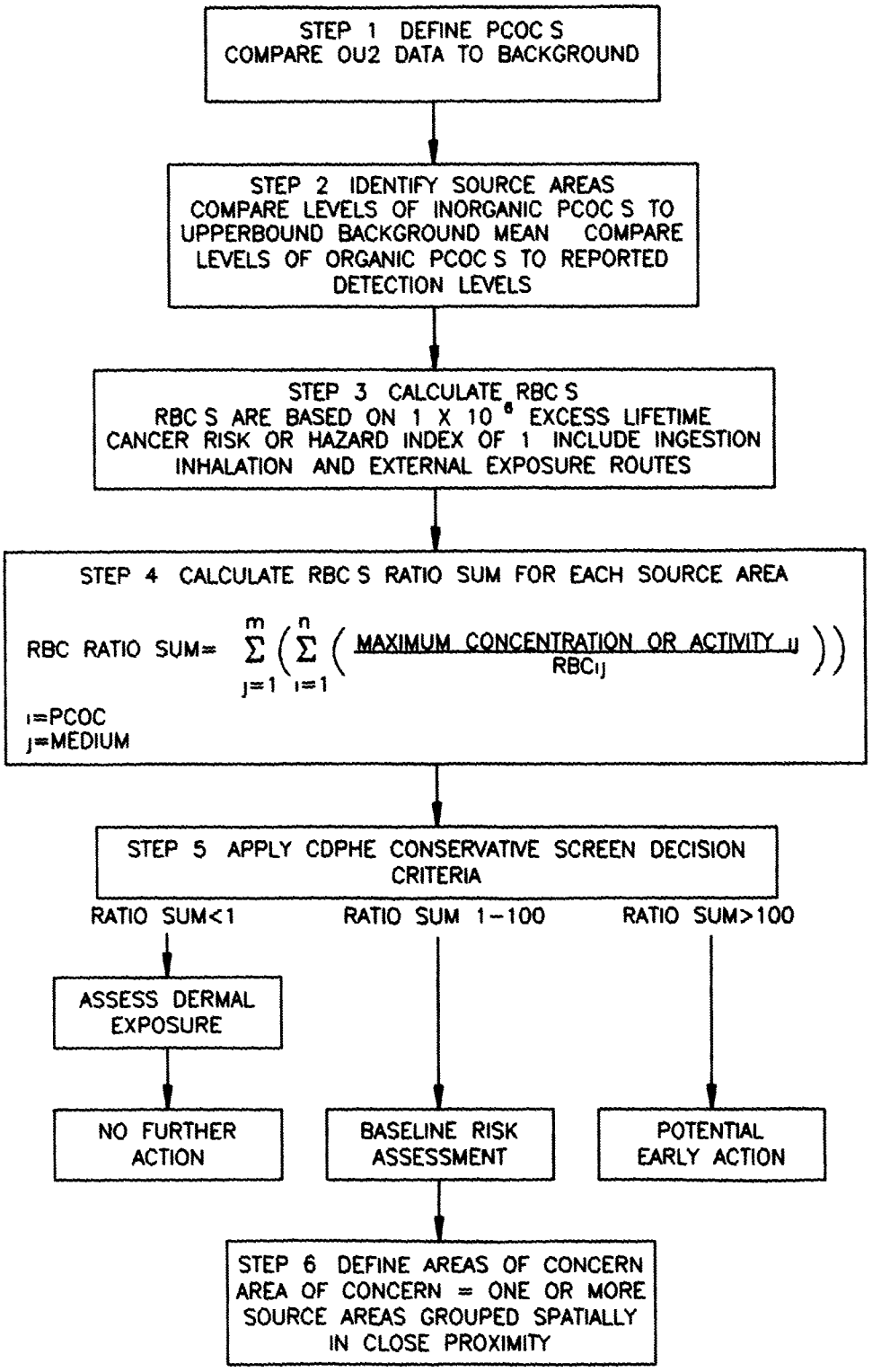
Golden Colorado

OPERABLE UNIT NO 2
CDPHE CONSERVATIVE SCREEN

AREA OF CONCERN
IDENTIFICATION PROCESS

FIGURE 1-2 SEPTEMBER 1994

CDPHE000 1 1



PHE = COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

= POTENTIAL CHEMICAL OF CONCERN

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 2
CDPHE CONSERVATVE SCREEN

2 0
IDENTIFICATION OF POTENTIAL CHEMICALS OF CONCERN

Step 1 of the CDPHE risk based screen is to identify PCOCs for OU2 PCOCs are defined as (a) metals and radionuclides significantly above background levels and (b) organic target analytes detected above reporting limits in surface soil subsurface soil or groundwater samples in OU2 The background determination was made on the basis of statistical comparison of OU2 data to background data The data sets used in the evaluation the background comparison process and the identification of PCOCs for OU2 are summarized in this section Greater detail is provided in the Draft Final Technical Memorandum No 9 Chemicals of Concern for HHRA at OU2 on RFETS (DOE 1994c)

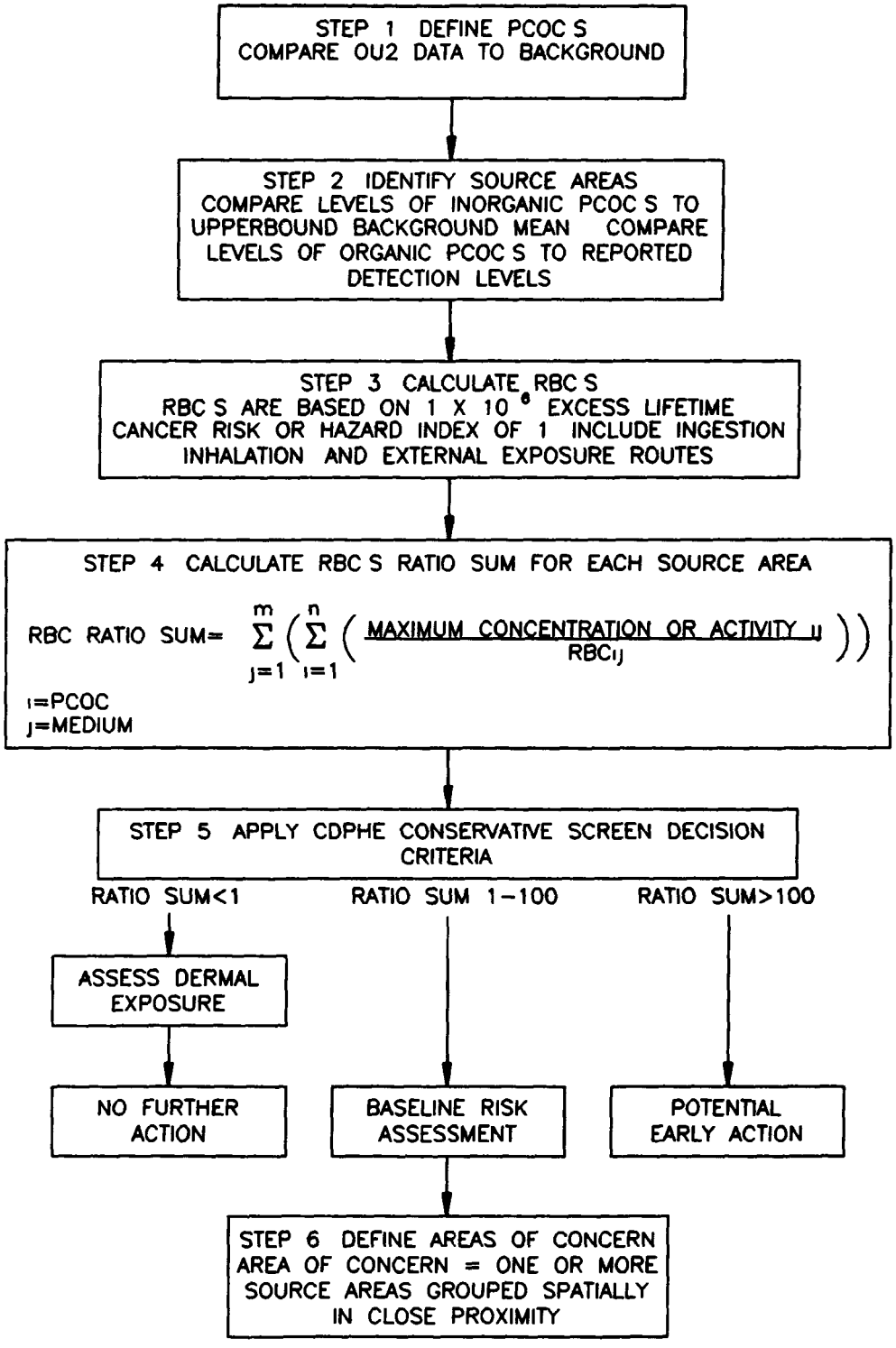
2 1 DATA USED FOR EVALUATION

Chemical analytical data from environmental samples collected during OU2 field sampling programs and Rocky Flats site wide sampling programs were evaluated to characterize contamination in OU2 Table 2 1 OU2 Analytical Data Summary describes which data were collected for each medium The data sets used for evaluation of surface soil subsurface soil and groundwater are described below

2 1 1 Surface Soil

The results of two separate sampling and analytical protocols (1991 92 and 1993) using surface soil samples from two depths were used to evaluate surface soil contamination in OU2 These programs were

- OU2 Phase II investigations conducted in 1991 and 1992 Some of the samples were collected by the Colorado Department of Health (CDH) method (0 25 inch deep samples) and some were collected by the modified Rocky Flats Plant (RFP) method (5 cm deep samples or approximately 2 inches deep) as described in the Preliminary Draft Phase II RFI/RI Report for OU2 (DOE 1993a)



CDPHE = COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

PCOC = POTENTIAL CHEMICAL OF CONCERN

RBC = RISK-BASED CONCENTRATION

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OPERABLE UNIT NO 2
CDPHE CONSERVATVE SCREEN

CDPHE CONSERVATIVE SCREEN PROCESS

FIGURE 1-3 SEPTEMBER 1994

CDPHED10 1 1

- OU2 Phase II investigation conducted in 1993 These samples were collected using the RFP sampling method (2 inch deep samples)

The surface soil sampling program and rationale is described in Technical Memorandum No 7 Surface Soil Sampling and Analysis Plan (DOE 1993b) The 1991 and 1992 surface soil samples were collected from 2 5 and 10 acre plots and the samples were analyzed for radionuclides The plots were selected for sampling based on results of previous investigations (DOE 1991) Samples collected using the CDH method were analyzed for americium plutonium and uranium Samples collected using the modified RFP method were analyzed for americium and plutonium only

The 1993 surface soil samples were collected from 100 foot by 150 foot plots All 1993 samples were collected using the RFP sampling method These samples were analyzed for semivolatile organic compounds (SVOCs) pesticides/polychlorinated biphenyls (PCBs) metals and radionuclides (except for americium plutonium and uranium)

Analytical results from surface soil samples from the three different sampling programs (CDH modified RFP and RFP) were used to evaluate the nature and extent of contamination As part of this evaluation inorganic chemical data collected using the modified RFP and RFP methods were compared to background data which were also collected using the RFP method For uranium only CDH method data were available for OU2 and those data were compared to background data from samples collected using the RFP method

Surface soil samples were collected within IHSSs as well as in grids extending across the whole OU The data set includes 69 samples analyzed for various metals between 13 and 80 samples analyzed for various radionuclides and 40 samples analyzed for SVOCs and pesticides/PCBs Surface soil sampling locations are shown in maps in Appendix B

2 1 2 Subsurface Soil

The data set for subsurface soil includes analytical results from over 350 samples collected during investigations in OU2 Data used to evaluate contamination in subsurface soil were taken from five sources

- OU2 Phase I field investigation conducted in 1987
- Boreholes for seismic evaluation drilled in 1989
- OU2 Phase II field investigation conducted from 1991 to 1993
- Well abandonment and replacement program conducted in 1992
- OU2 Soil Vapor Extraction (SVE) Pilot Program conducted in 1993

Many of the boreholes drilled for OU2 investigations were within IHSS boundaries Some boreholes from the other programs used to evaluate OU2 contamination were outside IHSS boundaries Borehole locations are shown in maps in Appendix C

For the background comparison and selection of PCOCs results from subsurface soil samples collected below the water table were excluded from the data set in order to delineate subsurface soil contamination from constituents transported by groundwater Laboratory analyses of borehole samples were based on project specific work plans and not all samples were analyzed for the same suite of analytes Approximately 380 samples were analyzed for volatile organic compounds (VOCs) SVOCs were analyzed for in 214 samples and pesticide/PCBs were analyzed for in 224 samples Various metals were analyzed for in 189 to 300 samples and various radionuclides were analyzed for in 49 to 284 samples

2 1 3 Groundwater

Groundwater samples were collected from monitoring wells on a quarterly basis under a site wide groundwater sampling program Samples were collected from more than 80 wells installed during OU2 Phase I and Phase II investigations and during other investigations conducted in 1987 and 1989 within the OU2 area

Only wells completed in the Upper Hydrostratigraphic Unit (UHSU) were included in the groundwater data set for the selection of PCOCs The UHSU includes the Rocky Flats alluvium colluvium valley fill alluvium Arapahoe (No 1) Sandstone weathered claystone of the Arapahoe and/or Laramie formations and subcropping Laramie Sandstones on the south facing slope of the Woman Creek drainage

The evaluation of contaminant concentrations in the UHSU was based on analytical results from samples collected from the second quarter of 1991 through the fourth quarter of 1992

The second quarter of 1991 was the first quarterly groundwater sampling event for which standard operating procedures (SOPs) and validation criteria were in place Samples collected prior to the second quarter of 1991 were inconsistently collected and validated In general the groundwater samples were analyzed for VOCs SVOCs pesticides/PCBs metals (filtered and unfiltered samples) radionuclides (filtered and unfiltered samples) and water quality parameters

Groundwater monitoring well locations are shown in maps in Appendix D

2 1 4 Data Review and Editing

The OU2 chemical analytical database includes all usable data available as of January 1994 Examples of unusable data include samples with no result or no units As of January 1994 74 percent of the data was validated Of the 26 percent that was not validated 18 percent is comprised of the 1987 borehole sample analytical results these samples were collected and analyzed prior to the current validation program

Data review and editing were performed in accordance with RFETS guidance The data review and editing process is described in the Preliminary Draft OU2 RFI/RI Report (DOE 1993a)

For radionuclides negative results were used as reported in accordance with DOE guidance that all results for radionuclides including negative ones should be included in statistical analysis Consequently there were no radionuclide non detects

2 2 BACKGROUND COMPARISON FOR INORGANIC CONSTITUENTS

Analytical results for metals and radionuclides were compared to background levels derived from data for subsurface soil and groundwater reported in the Background Geochemical Characterization Report (DOE 1993c) and from 18 background surface soil samples collected in the Rock Creek area during the 1991 OU1 Phase III investigation and the 1993 OU2 Phase II investigation Metals and radionuclides whose concentrations did not significantly exceed background levels were eliminated from further consideration as PCOCs

The methods used to evaluate whether a metal or radionuclide exceeded background levels are summarized below Attachment 1 presents summary tables of statistical results of the background comparison for metals and radionuclides in all media Technical Memorandum No 9 Chemicals of Concern (DOE 1994c) presents the background comparison methodology and results in more detail

- **Statistical tests** Analytical results for metals and radionuclides were compared to the background data using four statistical tests the Quantile test Slippage test Student s t test and the Gehan test as described in Gilbert s letter report (Gilbert 1993) Test conditions and treatment of non detect values are discussed in Technical Memorandum No 9 (DOE 1994c Appendix A) The analyte was considered to be significantly above background if it failed any test at the $p \leq 0\ 05$ level

- **$UTL_{99/99}$ comparison** Analytical results for each metal and radionuclide were compared to the 99 percent upper tolerance limit of background data calculated at the 99 percent confidence level ($UTL_{99/99}$) The $UTL_{99/99}$ test is an indicator of possible hot spots (Gilbert 1993) however with large sample sizes of one hundred to three hundred it is to be expected that a few OU2 data points would exceed the $UTL_{99/99}$ value Nevertheless if any result exceeded the $UTL_{99/99}$ the analyte was identified as a PCOC subject to spatial and temporal evaluation and assessment of the lognormal UTL

- **Lognormal $UTL_{99/99}$ comparison** The background $UTLs_{99/99}$ presented in the Background Geochemical Characterization Report (DOE 1993c) were calculated assuming that the background data were normally distributed This assumption may not be appropriate for all analytes Concentrations of some analytes were within background range according to all statistical tests performed but one or two results exceeded the background $UTL_{99/99}$ and therefore the analyte was identified as a PCOC When the distribution of the background data was tested if a log normal distribution was a better fit the $UTL_{99/99}$ was recalculated based on lognormal distribution and the OU2 results were compared to the lognormal based $UTL_{99/99}$ This statistical reevaluation

resulted in excluding some analytes as PCOCs (these analytes are noted on tables in Attachment 1)

2 2 1 Surface Soil Background Comparison

Table 2 2 lists the maximum detected concentrations and radioactivities and detection frequencies for metals and radionuclides identified as PCOCs in surface soil based on the statistical background comparison Background surface soil data consist of analytical results from samples collected at 18 locations in the Rock Creek area The results of the statistical comparisons to background data are summarized in Attachment 1 (Table 2 2 also lists organic PCOCs)

Chromium and lead were the only two non radioactive metals that were identified as PCOCs in surface soil based on the background comparison (other than calcium and iron which were removed from further evaluation because they are essential nutrients and silicon which is an element occurring extensively in the earth s crust and is not an environmental contaminant) The maximum lead concentration was 145 mg/kg which is below the EPA screening level of 400 mg/kg for residential soil (EPA 1994)

Chromium results were not significantly different than background according to the four formal statistical tests However two samples had results for chromium that exceeded the background $UTL_{99/99}$ of 24 8 mg/kg One result of 29 5 mg/kg was observed in a sample collected at location SS200893 which is in a non IHSS area approximately 700 feet south of the Southeast Trenches Another result of 28 mg/kg was measured in a sample collected at SS200193 which is in the 903 Pad area Sample locations are shown in Figure B 3 Because these two results somewhat exceeded the background $UTL_{99/99}$ chromium was retained as a PCOC in surface soil

Plutonium 239 240 (Pu 239 240) and americium 241 (Am 241) are the chief radionuclide PCOCs detected in surface soil Other radionuclide PCOCs are the uranium isotopes (U 238 U 235 and U 233 234) radium 226 and strontium 89 90 Elevated activities of these radionuclides (> background mean plus two standard deviations) are shown on Figures B 4 and B 5

2 2 2 Subsurface Soil Background Comparison

Table 2 3 lists the maximum detected concentrations and radioactivities and detection frequencies for metals and radionuclides identified as PCOCs in subsurface soil based on the statistical background comparison Background data for subsurface soils were taken from the Background Geochemical Characterization Report (DOE 1993c) The results of the statistical comparisons of OU2 inorganic data to background data are summarized in Attachment 1 Tables 2 3 and 2-4 also list organic PCOCs

Twelve metals and nitrate were identified as PCOCs in subsurface soil

Arsenic	Manganese
Barium	Mercury
Cadmium	Silver
Chromium	Vanadium
Cobalt	Zinc
Copper	Nitrate
Lead	

Concentrations exceeding the background mean plus two standard deviations are plotted on Figures C 5 (903 Pad Area) C 12 (Mound Area) C 19 (Northeast Trenches) C 26 (Southeast Trenches) and C 31 (East of IHSSs)

The radionuclides Pu 239 240 Am 241 U 233 234 U 238 U 235 radium 226 radium 228 cesium 137 and strontium 89 90 were also identified as PCOCs in subsurface soil Activities above the background mean plus two standard deviation are plotted in Figure C 6 and C 7 (903 Pad Area) C 13 and C 14 (Mound Area) C 20 and C 21 (Northeast Trenches) C 27 and C 28 (Southeast Trenches) and C 32 (East of IHSSs)

2 2 3 Groundwater Background Comparison

Table 2 5 lists the maximum detected concentrations and activities of metals and radionuclides identified as PCOCs in UHSU groundwater based on the statistical background comparison Data are shown for results from unfiltered samples

The results of the statistical background comparisons for inorganics are summarized in Attachment 1 Background data for UHSU groundwater were taken from the Background Geochemical Characterization Report (DOE 1993c) Inspection of Table 2 5 and the Attachment 1 tables for metals in unfiltered groundwater samples reveals that nearly all metals (including typical rock forming elements such as aluminum calcium iron and sodium) were identified as being above background levels Concentrations above the background mean plus two standard deviations are plotted in Figures D 7 through D 10 (metals) and D 13 (nitrate/nitrite) Most of the metals have been shown to be naturally occurring with elevated concentrations in groundwater due to local geochemical characteristics or high total suspended solids in unfiltered samples collected from wells with low yields More detailed evaluation is provided in Technical Memorandum No 9 Chemicals of Concern (DOE 1994c)

Several chlorinated solvents and other organic contaminants were detected in wells at maximum concentrations ranging from 0 3 μg/L for several compounds to 150 000 μg/L for trichloroethene Detection frequencies for volatile organic analytes ranged from 0 2 percent to 68 percent

2 3 SUMMARY OF PCOCs

Tables 2 2 through 2 6 list the organic and inorganic PCOCs in surface soil subsurface soil and UHSU groundwater including maximum detected concentrations activities and detection frequency The chief PCOCs in each medium are identified below

Summary of Chief PCOCs by Medium

Organic Compounds	Metals	Radionuclides
Surface Soil		
Polycyclic aromatic hydrocarbons	Chromium Lead	Pu 239 240 Am 241

Summary of Chief PCOCs by Medium (cont'd)

Organic Compounds	Metals* and Inorganics	Radionuclides
Subsurface Soil.		
1 1 1 Trichloroethane	Arsenic	Pu 239 240
Tetrachloroethene	Cadmium	Am 241
	Chromium	U 233 234
	Mercury	U 235
	Silver	U 238
	Vanadium	
Groundwater.		
1 1 Dichloroethene	Nitrate	Pu 239 240
1 1 1 Trichloroethane	Antimony	Am 241
Carbon tetrachloride	Arsenic	
Chloroform	Barium	
Methylene chloride	Beryllium	
Tetrachloroethene	Cadmium	
Trichloroethene	Manganese	
	Molybdenum	
	Nickel	
	Selenium	
	Vanadium	

* Metals in groundwater are probably naturally occurring

Organic PCOCs in surface soil are plotted on Figures B 1 and B 2 Organic PCOCs in subsurface soil are plotted on Figures C 1 through C 4 (903 Pad Area) C 8 through C 11 (Mound Area) C 15 through C 18 (Northeast Trenches) C 22 through C 25 (Southeast Trenches) and C 29 and C 30 (East of IHSSs) Organic PCOCs in groundwater are plotted in Figures D 1 through D 6

TABLE 2 1
ROCKY FLATS PLANT OU2
ANALYTICAL DATA SUMMARY

Data Description Borehole	Data Used for Identifying PCOCs
Metals 1987	All subsurface soil data from above high water table
Metals 1991 1992	All subsurface soil data from above high water table
Pesticides/PCBs 1987	All subsurface soil data from above high water table
Pesticides/PCBs 1991 1992	All subsurface soil data from above high water table
Radionuclides 1987	All subsurface soil data from above high water table
Radionuclides 1991 1992	All subsurface soil data from above high water table
SVOCs 1987	All subsurface soil data from above high water table
SVOCs 1991 1992	All subsurface soil data from above high water table
VOCs 1987	All subsurface soil data from above high water table
VOCs 1991 1992	All subsurface soil data from above high water table

Data Description Groundwater		Data Used for Identifying PCOCs
Pesticides/PCBs	1st and 2nd Quarters 1992	1st and 2nd Quarter 1992
Pesticides/PCBs	All Quarters 1991	2nd through 4th Quarter 1991
Dissolved Radionuclides	1st and 2nd Quarters 1992	1st and 2nd Quarter 1992
Total Radionuclides	1st and 2nd Quarters 1992	1st and 2nd Quarter 1992
Dissolved Radionuclides	3rd and 4th Quarters 1992	3rd Quarter 1992
Total Radionuclides	3rd and 4th Quarters 1992	3rd Quarter 1992
Dissolved Radionuclides	All Quarters 1990	Not Used
Total Radionuclides	All Quarters 1990	Not Used
Dissolved Radionuclides	All Quarters 1991	2nd through 4th Quarter 1991
Total Radionuclides	All Quarters 1991	2nd through 4th Quarter 1991
SVOCs	1st and 2nd Quarters 1992	1st and 2nd Quarter 1992
SVOCs	4th Quarter 1991	4th Quarter 1991
VOCs	1st and 2nd Quarters 1992	1st and 2nd Quarter 1992
VOCs	3rd and 4th Quarters 1992	3rd Quarter 1992
VOCs	All Quarters 1990	Not Used
VOCs	All Quarters 1991	2nd through 4th Quarter 1991
Water Quality Parameters	1st and 2nd Quarters 1992	Not Used
Water Quality Parameters	3rd and 4th Quarters 1992	Not Used
Water Quality Parameters	All Quarters 1990	Not Used
Water Quality Parameters	All Quarters 1991	Not Used
Metals	1st Quarter 1990 4th Quarter 1992	2nd Qtr 1991 3rd Qtr 1992

Data Description Surficial Soil	Data Used for Identifying PCOCs
1993 data not including background (met rads sv pest)	All
1991 and 1992 data (rads)	All

PCOC = Potential Chemical of Concern

TABLE 2 2
ROCKY FLATS OU2
POTENTIAL CHEMICALS OF CONCERN
IN SURFACE SOIL

	Maximum Detected Conc (mg/kg)	Detection Frequency /
Organic Compounds		
4 4 DDT	0 026	3
Aroclor 1254	0 97	5
Aroclor 1260	0 66	5
Benzo(a)anthracene	0 16	18
Benzo(a)pyrene	0 16	18
Benzo(b)fluoranthene	0 24	23
Benzo(k)fluoranthene	0 076	5
Benzo(ghi)perylene	0 045	3
Benzoic acid	0 7	93
Bis(2-ethylhexyl)phthalate	0 51	23
Chrysene	0 2	28
delta BHC	0 023	3
Di n Butylphthalate	1 0	3
Fluoranthene	0 39	48
Indeno(1 2 3-cd)pyrene	0 083	5
Phenanthrene	0 23	30
Pyrene	0 35	55
Metals		
Chromium	29 5	100
Lead	145	100

	Maximum Detected Activity (pCi/g)	
Radionuclides[1]		
Plutonium 239 240	7300	100
Americium 241	160	100
Uranium 238	7 74	100
Uranium 233 234	3 58	100
Uranium 235	0 68	100
Radium 226	1 46	100
Strontium 89 90	2 09	100

[1] Detection frequency of radionuclides is designated as 100 % because both positive and negative analytical results are used in the data set for statistical analysis

TABLE 2 3
ROCKY FLATS OU2
POTENTIAL CHEMICALS OF CONCERN IN SUBSURFACE SOIL
DETECTED AT 5% OR GREATER FREQUENCY

	Maximum Detected Conc [1] (mg/kg)	Detection Frequency /
Organic Compounds		
1 1 1 Trichloroethane	13	5
1 2 Dichloroethane	0 12	9
2 Butanone	0 15	6
Acetone	26	38
Bis(2-ethylhexyl)phthalate	12	38
Di n butylphthalate	3 4	26
Methylene chloride	29	28
N nitrosodiphenylamine	0 28	13
Tetrachloroethene	13000	13
Toluene	7 6	38
Metals		
Arsenic	30 8	94
Barium	589	83
Cadmium	10 5	34
Chromium	127	98
Cobalt	38 5	53
Copper	132	86
Lead	86 4	100
Manganese	3160	100
Mercury	114	24
Silver	96 5	13
Vanadium	80 4	97
Zinc	437	100
Nitrate	4 3	42

TABLE 2 3
(concluded)

	Maximum Detected Conc [1] (mg/kg)	Detection Frequency /
Radionuclides[2]		
Plutonium 239 240	180	100
Americium 241	22	100
Uranium 233 234	191 7	100
Uranium 235	11 5	100
Uranium 238	113 1	100
Radium 226	1 9	100
Radium 228	6 3	100
Cesium 137	4 7	100
Strontium 89 90	1 1	100

[1] In samples collected to 12 feet below ground surface

[2] Detection frequency of radionuclides is designated as 100 / because both positive and negative analytical results are used in the data set for statistical analysis

TABLE 2-4
ROCKY FLATS OU2
ORGANIC POTENTIAL CHEMICALS OF CONCERN IN SUBSURFACE SOIL
DETECTED AT LESS THAN 5% FREQUENCY

	Maximum Detected Conc [1] (mg/kg)	Detection Frequency /
Organic Compounds		
1 1 2 2 Tetrachloroethane	0 005	0 3
1 2 Dichloroethene	0 09	1
1 3 Dichloropropene cis	0 006	0 3
1 4 Dichlorobenzene	0 043	0 5
2 Chloroethyl vinyl ether	0 031	1
2 Methylnaphthalene	8 1	1
2 Methylphenol	0 45	0 5
4 4 DDT	0 14	0 4
4 Methyl 2 pentanone	0 011	0 3
4 Methylphenol	2 9	0 5
4 Nitroaniline	1 6	0 5
Acenaphthene	0 28	1
Anthracene	0 26	0 5
Aroclor 1254	8 9	3
Benzene	0 012	0 3
Benzo(a)anthracene	0 53	0 5
Benzo(a)pyrene	0 48	1
Benzo(b)fluoranthene	0 82	0 5
Benzo(ghi)perylene	0 36	0 5
Benzoic acid	0 4	1
Butyl benzylphthalate	0 52	0 5
Carbon disulfide	0 14	0 3
Carbon tetrachloride	140	4
Chloroethane	0 007	0 3
Chloroform	8 8	3
Chrysene	0 42	1
Di n octylphthalate	0 26	0 5
Ethylbenzene	0 026	2
Fluoranthene	1	2
Fluorene	0 19	0 5
Hexachlorobutadiene	0 17	0 5
Hexachloroethane	1 1	0 5
Indeno(1 2 3-cd)pyrene	0 33	0 5
Naphthalene	2	1
Pentachlorophenol	0 095	1
Phenanthrene	2 7	2
Pyrene	1 3	2
Styrene	0 017	0 3
Xylenes	0 23	4
Trichloroethene	120	4

[1] In samples collected to 12 feet below ground surface

TABLE 2 5
ROCKY FLATS OU2
POTENTIAL CHEMICALS OF CONCERN IN GROUNDWATER
DETECTED AT 5% OR GREATER FREQUENCY

	Maximum Detected Conc (mg/L)	Detection Frequency /
Organic Compounds		
1 1 1 Trichloroethane	1	25
1 1 Dichloroethane	0 66	13
1 1 Dichloroethene	0 38	26
1 2 Dichloroethene	0 17	34
1 2 Dichloroethene cis	1 70	45
1 2 Dichloroethene trans	0 03	8
Acetone	0 28	6
Benzene	0 038	5
Bis(2-ethylhexyl)phthalate	0 017	29
Bromodichloromethane	0 19	6
Carbon tetrachloride	20	60
Chloroform	39	55
Diethyl phthalate	0 31	11
Methylene chloride	35	18
Naphthalene	0 085	9
Tetrachloroethene	14	68
Toluene	0 11	10
Trichloroethene	150	61
Metals and other inorganics (unfiltered samples)		
Aluminum	1460	99
Antimony	0 297	22
Arsenic	0 021	60
Barium	11 3	94
Beryllium	0 114	43
Cadmium	0 078	25
Chromium	3 36	77
Cobalt	0 651	61
Copper	1 31	66
Lead	0 675	93
Lithium	0 842	86
Manganese	24	99
Mercury	0 005	13
Molybdenum	0 389	25
Nickel	2 01	76
Selenium	0 3	32
Silver	0 057	12
Strontium	4 24	100
Thallium	0 006	13
Tin	0 642	15
Vanadium	3 14	83
Zinc	5 29	96
Nitrate	444	92

TABLE 2 5
(concluded)

	Maximum Detected Activity (pCi/L)	Detection Frequency /
Radionuclides		
Plutonium 239 240	354 6	100
Americium 241	46 54	100
Strontium 89 90	6 7	100
Cesium 137	1 799	100

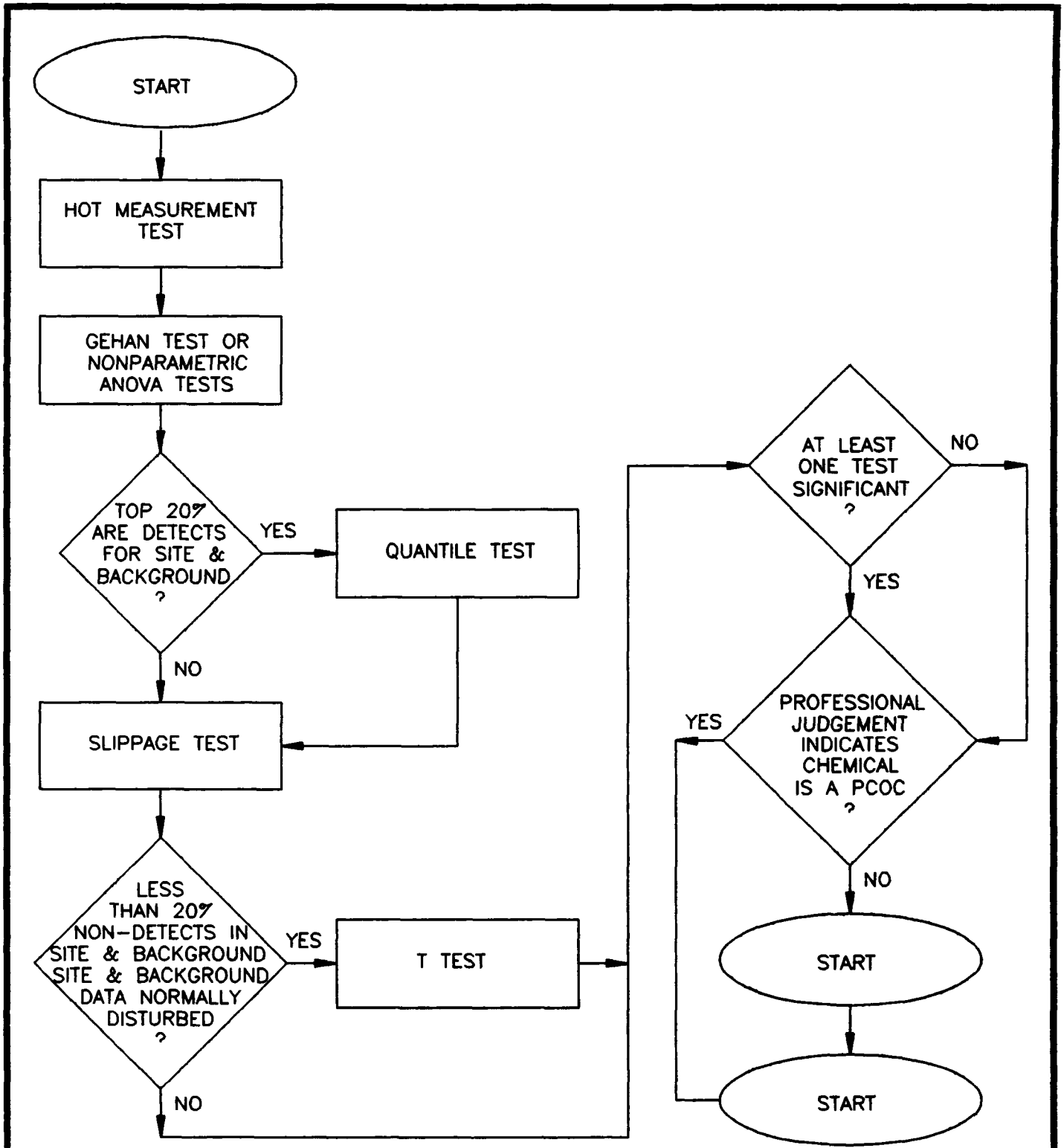
(1) Detection frequency of radionuclides is designated as 100 / because both positive and negative analytical results are used in the data set for statistical analysis

TABLE 2-6
ROCKY FLATS OU2
ORGANIC POTENTIAL CHEMICALS OF CONCERN IN GROUNDWATER DETECTED AT LESS THAN 5% FREQUENCY

	Maximum Detected Conc (mg/L)	Detection Frequency /
Organic Compounds		
1 1 1 2 Tetrachloroethane	0 003	3
1 1 2 2 Tetrachloroethane	0 18	2
1 1 2 Trichloroethane	0 021	2
1 1 Dichloropropene	0 0001	0 4
1 2 3 Trichlorobenzene	0 0004	2
1 2 3 Trichloropropane	0 002	1
1 2 4 Trichlorobenzene	0 002	1
1 2 4 Trimethylbenzene	0 0006	1
1 2 Dibromo 3-chloropropane	0 004	1
1 2 Dibromoethane	0 013	1
1 2 Dichloroethane	0 006	2
1 2 Dichloropropane	0 001	0 2
1 3 Dichloropropene cis	1 6	1
1 3 Dichloropropene trans	0 008	1
1 3 Dichlorobenzene	0 002	1
1 3 Dichloropropane	0 0003	0 4
1 3 5 Trimethylbenzene	0 001	1
1 4 Dichlorobenzene	0 0003	1
2 Hexanone	0 005	1
4 Methyl 2 pentanone	0 01	1
Benzoic acid	0 056	3
Bromobenzene	0 001	1
Bromochloromethane	0 71	2
Bromoform	0 006	1
Bromomethane	0 001	0 3
Carbon disulfide	0 0005	1
Chlorobenzene	0 016	1
Chloroethane	0 002	1
Chloromethane	0 32	1
Di n-butylphthalate	0 003	3
Dibromochloromethane	0 002	0 2
Dibromomethane	1 7	0 4
Dichlorodifluoromethane	0 005	1
Ethylbenzene	0 015	1
Heptachlor epoxide	0 00007	3
Hexachlorobutadiene	0 0006	2
m+p Xylene	0 0003	2
m Xylene	0 0003	2
n Butylbenzene	0 001	1
o Chlorotoluene	0 0003	0 4
o Xylene	0 0003	2

TABLE 2 6
(concluded)

	Maximum Detected Conc (mg/L)	Detection Frequency /
p Chlorotoluene	0 0003	0 3
p Cymene	0 0001	3
p Xylene	0 0002	1
sec Butylbenzene	0 23	4
Styrene	0 014	2
tert Butylbenzene	0 0004	0 3
Trichlorofluoromethane	0 0006	3
Vinyl chloride	0 86	3
Xylenes total	0 053	1



PCOC POTENTIAL CHEMICAL OF CONCERN

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 2
CDPHE CONSERVATIVE SCREEN

BACKGROUND COMPARISON PROCESS

FIGURE 2-1 AUGUST 1994

CDPHE002

3 1 RATIONALE FOR SOURCE AREAS

A source area is defined as an IHSS or group of IHSSs where concentrations or activities of PCOCs in soil or groundwater exceed an upper bound estimate of the background range The upper bound estimate of the background range for metals and radionuclides is defined as the background mean plus two standard deviations detected organic compounds are considered to be above background levels The background comparison methodology and identification of PCOCs were described in Section 2 0

Source areas in OU2 were delineated by evaluating the concentrations and distribution of PCOCs in three media (surface soil subsurface soil and groundwater) Source areas include contaminated soil and associated groundwater contaminant plumes if any To assist in the delineation of contaminant source areas concentrations and activities of inorganic PCOCs above the background mean plus two standard deviations and detected concentrations of organic compounds were plotted by medium The plots for PCOCs in surface soil are shown in Appendix B Figures B 1 through B 5 Plots for PCOCs in subsurface soil are shown in Appendix C Figures C 1 through C 32 Plots for PCOCs in groundwater are shown in Appendix D Figures D 1 through D 13

Five source areas are identified in OU2 these are listed below and illustrated in Figure 3 1 IHSSs are identified in Figure 1 1 The physical extent of source areas 1 2 and 3 are largely determined by the extent of associated contaminant plumes in groundwater The rationale for their delineation is presented in more detail in the rest of this section The five source areas are

(1) 903 Pad Source Area including (a) IHSSs 109 (Trench T 2) 112 (903 Pad) 140 (Reactive Metal Destruction Site) 155 (903 Lip Area) and 183 (Gas Detoxification Area) at the 903 Pad area (b) a groundwater contaminant plume extending north and northeast of the 903 Pad area toward the South Walnut Creek drainage and extending south and southeast of the 903 Pad area

toward the Woman Creek drainage and (c) surface soil and subsurface soil within the area defined by the extent of the groundwater plume The plume boundary incorporates a portion of Trench T 5 (IHSS 111 2) Trenches T 9 (IHSS 111 6) T 10 (IHSS 111 7) T 11 (IHSS 111 8) T 12 and T 13 and most of the East Spray Fields (IHSSs 216 2 and 216 3) These trenches and spray fields are located within the area defined by the extent of groundwater contaminant plume but probably do not contribute to it

(2) Mound Source Area including (a) IHSSs 108 (Trench T 1) 113 (Mound Area) 153 (Oil Burn Pit No 2) and 154 (Pallet Burn Site) in the Mound area (b) a groundwater contaminant plume extending north and northeast of the Mound area toward the South Walnut Creek drainage and (c) surface soil and subsurface soil within the area approximately defined by (a) and (b)

(3) Northeast Trenches Source Area including (a) Trenches T 3 and T 4 (IHSSs 110 and 111 1) (b) a groundwater contaminant plume extending north of Trenches T 3 and T 4 toward the South Walnut Creek drainage and (c) surface soil and subsurface soil located within the area defined by the extent of the groundwater plume

(4) Southeast Trenches Source Area including (a) the portion of Trench T 5 (IHSS 111 2) that has no underlying groundwater and Trenches T 6 (IHSS 111 3) T 7 (IHSS 111 4) and T 8 (IHSS 111 5) and (b) surface soil and subsurface soil within the area approximately defined by (a) No UHSU groundwater is present in this area

(5) East of IHSSs Source Area including (a) UHSU groundwater east of the previously described source areas extending to Indiana Street and bounded by South Walnut Creek to the north and Woman Creek to the south and (b) surface soil and subsurface soil within the area defined in (a) There are no IHSSs in this area with the exception of a portion of the East Spray Field (IHSS 216 3)

The following subsections describe the concentrations and distribution of PCOCs in the three media Surface soil PCOCs are presented on an OU wide basis but the subsurface soil and groundwater PCOCs are presented by source area

3 2 SURFACE SOIL

Surface soil samples were collected across OU2 in a grid pattern extending to Indiana Street however some sample locations were biased toward high concentrations and specifically collected in IHSSs The chief PCOCs in surface soil are Am 241 Pu 239 240 and polycyclic aromatic hydrocarbons (PAHs) Am 241 and Pu 239 240 are widely distributed in surface soil (Figure B 4) due to wind dispersion from historic releases near and within the industrialized portion of the plant PAHs (which can result from vehicle traffic or other commonplace combustion sources) are widely distributed across the site and are believed to be the result of anthropogenic sources rather than waste related contamination (Figure B 1) Consequently the distribution of PCOCs in surface soil did not provide a meaningful guide to identifying contaminant source areas in OU2 Therefore subsurface soil and groundwater contamination were used as the basis for delineating source areas

3 3 903 PAD SOURCE AREA

The extent of the 903 Pad Source Area is shown in Figures 3 1 and A 2 It includes IHSSs at the 903 Pad area and soil and groundwater within the area defined by the groundwater contaminant plume extending from the 903 Pad area

In subsurface soil at this source area the chief contaminants observed were chlorinated solvents at Trench T 2 (IHSS 109) Am 241 and Pu 239 240 at the 903 Pad (IHSS 112) the Reactive Metal Destruction Site (IHSS 140) the 903 Lip Area (IHSS 155) and the polychlorinated biphenyl (PCB) Aroclor 1254 (detected at about 6 mg/kg in the 2 to 8 foot interval in boring 8691 at the 903 Pad) For example maximum concentrations of tetrachloroethene (PCE 10 mg/kg at 15 feet in BH2587) and trichloroethene (TCE 16 mg/kg at 19 feet in BH2587) were detected in subsurface soil at Trench T 2 Maximum concentrations are lower in the 0 to 12 foot interval evaluated in the risk based screen For example maximum concentrations of PCE and TCE in this interval were 0 13 mg/kg and 0 1 mg/kg respectively both in BH2587 at Trench T 2 VOCs were detected in lower

concentrations (about 0 4 mg/kg or less) in subsurface soil beneath the 903 Pad and other IHSSs in the vicinity of the 903 Pad Concentrations of VOCs are relatively constant or increase with depth and extend to the water table

Am 241 (at 12 to 25 pCi/g) and Pu 239 240 (at 68 to 180 pCi/g) were observed in subsurface soil samples beneath and east of the 903 Pad to depths of about 20 feet Radionuclide activities tend to decrease with depth below ground surface These radionuclides were detected at lower levels (0 2 to 6 pCi/g) in subsurface soil at Trench T 2 and in samples collected outside of the IHSS boundaries

UHSU groundwater in the vicinity of the 903 Pad is contaminated with chlorinated solvents Elevated levels of metals and radionuclides were also observed in unfiltered samples Solvents in subsurface soil in the vicinity of the 903 Pad (IHSS 112) and Trench T 2 (IHSS 109) are the probable source of organic contaminants in groundwater Maximum concentrations of carbon tetrachloride (20 mg/L in well 06691) chloroform (39 mg/L in well 06691) methylene chloride (35 mg/L in well 06691) and PCE (14 mg/L in well 08891) were observed in alluvial groundwater near the 903 Pad (IHSS 112) The maximum concentration of TCE (140 mg/L in well 07391) was observed in alluvial/colluvial groundwater near Trench T 2 (IHSS 109)

Alluvial groundwater flowing east northeast from the 903 Pad follows an alluvium filled bedrock paleoscour and discharges to the South Walnut Creek drainage at a surface seep located south of Pond B 5 Contaminant concentrations decrease with distance to the east northeast away from the 903 Pad area Alluvial groundwater flowing south southeast from the 903 Pad area discharges to colluvium on the south facing slope of the Woman Creek Drainage Concentrations decrease with distance south southeast from the 903 Pad and decrease with distance south from Trench T 2 (IHSS 109)

The No 1 Sandstone unit of the UHSU subcrops beneath the alluvium immediately west of the 903 Pad (IHSS 112) and beneath the bedrock paleoscour east of the 903 Pad Groundwater within the No 1 Sandstone flows north toward the South Walnut Creek drainage and south toward the Woman Creek drainage Contaminant concentrations within the No 1 Sandstone decrease with distance away from the 903 Pad area However in the

vicinity of the Northeast Trenches contaminant concentrations within the No 1 Sandstone increase significantly

Am 241 and Pu 239 240 were detected at maximum activities of 46 5 and 180 pCi/L respectively (at the 903 Pad [IHSS 112] well 09091) in unfiltered groundwater samples

A portion of Trench T 5 (IHSS 111 2) Trenches T 9 through T 11 (IHSS 111 6 through 111 8) and Trenches T 12 and T 13 are located within the area defined by the groundwater plume extending from the 903 Pad area However these trenches do not appear to be sources of groundwater contamination because the concentrations observed in groundwater at these trenches are similar to upgradient concentrations

Subsurface soil samples collected at these trenches show negligible to low levels of organic contamination For example the maximum concentration of any volatile organic analyte was 0 2 mg/kg of acetone at approximately 22 feet below ground surface in BH5387 in Trench T 5 IHSS 111 2 However several subsurface soil samples contained Am 241 and Pu 239 240 above background levels For example the maximum activity of Am 241 was 0 16 pCi/g (at 28 feet below ground surface in BH4787 just north of Trench T 9 IHSS 111 6) and the maximum activity of Pu 239 240 was 0 253 pCi/g (in the 2 to 8 foot interval in borehole 07891 in Trench T 11 IHSS 111 8)

Because Trench T 5 and Trenches T 9 through T 13 do not appear to be a source of contamination to groundwater but are located within the area defined by the groundwater plume extending from the 903 Pad area they are considered within the 903 Pad Source Area

3 4 MOUND SOURCE AREA

The Mound Source Area is shown in Figures 3 1 and A 2 It incorporates IHSSs at the Mound area (Figure 1 1) and a groundwater contaminant plume extending north and northeast from the Mound area IHSSs toward the South Walnut Creek drainage

Releases from former drum storage activities at IHSS 113 (the Mound Site) are suspected to be the chief source of soil and groundwater contamination in the Mound Source Area In subsurface soil concentrations of chlorinated solvents such as PCE and TCE increase with

depth to about 25 feet then decrease to a depth of about 50 feet For example the maximum detected concentration of PCE in subsurface soil was 0 180 mg/kg at about 20 feet below ground surface (borehole 09991) decreasing to 0 007 mg/kg at 50 feet in adjacent borehole 21793 (Figure C 8) These concentrations are low and do not suggest the presence of a continuing source to groundwater at the locations sampled However a soil vapor survey conducted in this area detected a single location at 10 feet below ground surface in IHSS 113 that exhibited a high concentration of total VOCs (> 35 000 μg/L) in IHSS 113 (DOE 1994c) Aroclor 1254 was detected in two samples at 0 07 and 0 21 mg/kg Figure C 11) Am 241 (maximum activity of 0 48 pCi/g) Pu 239 240 (maximum activity of 2 6 pCi/g) and U 238 (maximum activity of 3 1 pCi/g) were also detected above background levels in subsurface soils in this area (Figure C 13)

UHSU groundwater in the Mound Source Area is contaminated with chlorinated solvents (primarily TCE and PCE) and radionuclides above background levels in unfiltered samples For example maximum concentrations of PCE (13 mg/L) and TCE (0 41 mg/L) were observed in well 02091 in the No 1 Sandstone to the north and northeast of the Mound Site (IHSS 113) (Figure D 2) The alluvium is only saturated during the high water period (usually in the second quarter i e April through June) when the paleoscour fills Groundwater contamination extends north toward the South Walnut Creek drainage Vinyl chloride has also been detected (maximum concentration of 0 86 mg/L) in well 3586 north of the Mound Area (Figure D 3) but the source is unknown since this compound has not been detected in upgradient wells in OU2 Well 3586 is screened in the valley fill alluvium

Chlorinated solvents Am 241 and Pu 239 240 have also been observed in seep water samples collected north of the Mound Area in the South Walnut Creek drainage

3 5 NORTHEAST TRENCHES SOURCE AREA

The Northeast Trenches Source Area is shown in Figures 3 1 and A 2 It incorporates Trenches T 3 (IHSS 110) and Trench T 4 (IHSS 111 1) and a groundwater contaminant plume extending north toward the South Walnut Creek drainage

Contaminants released from buried materials in Trenches T 3 and T 4 are the probable sources of subsurface soil and groundwater contamination in this area Concentrations of

chlorinated hydrocarbons in subsurface soil decrease with depth but extend to the water table (Figure C 15) Maximum concentrations of carbon tetrachloride (700 mg/kg at 16 feet in boring 10191) chloroform (8 8 mg/kg at 3 feet in boring 10191) 1 1 1 trichloroethane (27 mg/kg at 16 feet in boring 10191) PCE (13 000 mg/kg at 3 feet in boring 10191) and TCE (120 mg/kg at 3 feet in boring 10191) were detected Boring 10191 is located in Trench T 3 (IHSS 110) Nonaqueous phase VOCs were also observed in this borehole PAHs DDT and Aroclor 1254 were detected in the 2 to 8 foot interval in boring 10291 in Trench T 4 (Figures C 17 and C 18) Several metals were also observed in concentrations exceeding background levels (Figure C 19) Elevated concentrations of arsenic lead and silver were observed in samples at Trench T 3 elevated levels of beryllium cadmium chromium copper lead silver and zinc were observed in subsurface soil samples at Trench T 4 Some of these metals may be naturally occurring

Several radionuclides (Am 241 Pu 239 240 and uranium isotopes) were also observed at activities above background levels in subsurface soil (Figure C 20)

The Northeast Trenches are located at the northern edge of the saturated alluvium in OU2 therefore the alluvium is saturated only intermittently Groundwater in the No 1 Sandstone flows north and discharges to colluvium in the South Walnut Creek drainage

Groundwater contamination in the vicinity of the Northeast Trenches appears to be derived from contaminants released from Trenches T 3 and T 4 Chlorinated hydrocarbons were observed in the alluvium in the paleoscour immediately east of Trench T-4 and in the No 1 Sandstone beneath and to the north of the trenches For example maximum concentrations of TCE (94 mg/L in well 3687) carbon tetrachloride (4 5 mg/L in well 12691) and PCE (1 mg/L in well 12691) were detected VOC contamination extends north toward the South Walnut Creek drainage near Ponds B-1 and B 2 and based on vegetation is believed to discharge above or into these ponds

3 6 SOUTHEAST TRENCHES SOURCE AREA

The Southeast Trenches Source Area is shown in Figures 3 1 and A 2 The source area includes surface soil and subsurface soil at and in the vicinity of T 5 through T 8 (IHSSs 111 2 through 111 5) Portions of the Southeast Trenches area where groundwater is present

have been excluded so there is no groundwater associated with this source area The low concentrations of PCOCs detected in subsurface soil do not appear to contribute to groundwater contamination detected in alluvial wells to the north and east (Groundwater contamination to the north and east is attributed to contaminant sources at the 903 Pad Source Area)

In general VOC levels in subsurface soil in the Southeast Trenches Source Area are low (Figures C 22 and C 23) VOCs measured in subsurface soil samples collected at Trenches T 5 through T 8 were

(a) the common laboratory contaminants acetone (5 to 31 μg/kg in undiluted samples) 2 butanone (1 to 67 μg/kg) and methylene chloride (4 to 17 μg/kg)

(b) toluene which is a suspected field contaminant (2 to 56 μg/kg in undiluted samples)

(c) trace concentrations (2 to 5 μg/kg) of ethylbenzene and the chlorinated hydrocarbons chloroform 1 1 1 trichloroethane and PCE

(d) low concentrations of 1 2 dichloroethane (5 to 100 μg/kg) and

(e) trace concentrations of xylenes (2 to 18 μg/kg)

Maximum concentrations of bis(2 ethylhexyl)phthalate (66 J μg/kg) (a common laboratory contaminant) N nitrosodiphenylamine (84 J μg/kg) and pentachlorophenol (41 J μg/kg) were also detected (Figure C 24) These compounds were detected in 1 to 6 samples out of approximately 60 samples analyzed for semivolatiles In addition some metals (arsenic barium cadmium lead and strontium) and Am 241 and Pu 239 240 were detected at concentrations above background in some subsurface soil samples (Figures C 26 and C 27)

3 7 EAST OF IHSSs SOURCE AREA

This area includes the soil and groundwater east of the OU2 IHSSs beyond the previously described source areas (Figures 3 1 and A 2) There are no IHSSs within this source area

with the exception of a portion of the East Spray Field (IHSS 216 3) PCOCs in surface soil in this area include Am 241 and Pu 239 240 (Figure B 4) and widespread occurrences of low concentrations (less than 0 2 mg/kg) of individual PAHs (Figure B 1) which are probably attributable to vehicle emissions or other commonplace combustion sources Groundwater wells in this area include four wells on the pediment south of the B 5 Pond beyond the main discharge point (seep) of the 903 Pad plume one well in the colluvium on the south facing slope of the Walnut Creek drainage and five wells along Indiana Street Volatile organic PCOCs in groundwater are limited to trace levels Examples of maximum detected concentrations are TCE (0 7 μg/L) PCE (0 7 μg/L) methylene chloride (0 6 μg/L) and chloroform (0 4 μg/L) in wells on the pediment south of the B 5 pond (South Walnut Creek) and methylene chloride (3 3 μg/L) PCE (0 11 μg/L) and TCE (0 4 μg/L) in Well 41591 at Indiana Street These data are shown in Figures D 1 through D 4 Am 241 (maximum activity of 0 47 pCi/L) and Pu 239 240 (maximum activity of 2 2 pCi/L) were also measured in some samples from wells at Indiana Street (Figure D 11) Several metals are identified as PCOCs in groundwater on the basis of unfiltered samples these metals are associated with high suspended solids in the unfiltered samples (resulting from difficulty in sampling wells with low yields)

RBCs are chemical concentrations in soil and groundwater that are not expected to pose a health risk even under long term exposure They are calculated using conservative assumptions regarding exposure toxicity and acceptable risk The purpose of developing chemical specific RBCs and comparing them to concentrations of PCOCs at each source area is to provide preliminary screening level information on the relative magnitude of chemical contamination at source areas and to identify those PCOCs that may pose a human health risk assuming long term exposure to maximum detected concentrations This information can be used in the preliminary selection of remedial alternatives prior to the completion of the HHRA and can also identify source areas where no further action is required RBCs should not be used as a substitute for a complete HHRA as a stand alone decision making tool or as site specific cleanup levels

For this risk based screen RBCs were calculated assuming long term residential exposure to soil and groundwater RBCs for residential exposure to soil are calculated assuming ingestion inhalation of particulates and external radiation pathways RBCs for groundwater are calculated assuming ingestion and inhalation of VOCs released during domestic use Separate RBCs are calculated for carcinogenic and noncarcinogenic effects of chemicals RBCs for carcinogens are calculated based on a 1 in 1 000 000 (10^{-6}) excess cancer risk level RBCs for noncancer effects of chemicals are calculated based on a hazard quotient of 1 (DOE 1994b) General equations for calculating RBCs are

$$\textit{Carcinogenic RBC} = \frac{\textit{Target Cancer Risk Level}}{\textit{Intake Factor x Cancer Slope Factor}}$$

$$\textit{Noncarcinogenic RBC} = \frac{\textit{Target Hazard Index x Reference Dose}}{\textit{Intake Factor}}$$

The target cancer risk is equal to 10^{-6} and the target hazard index is equal to 1 The reference doses (RfDs) and cancer slope factors (SFs) are chemical specific EPA established toxicity factors they are presented in DOE 1994b Intake factors are an assumption of daily intake of soil or groundwater per kilogram body weight The exposure parameters and other factors used to derive the intake factors for calculating RBCs are discussed in detail below All exposure assumptions are EPA standard default values (EPA 1991a)

4 1 RESIDENTIAL EXPOSURE TO SOIL

RBCs for residential exposure to chemicals in soil were calculated using standard toxicity values (RfDs for noncancer effects and SFs for carcinogenic effects) established by EPA (DOE 1994b) Ingestion inhalation of particulates and external radiation are the exposure routes used in calculating residential soil RBCs To calculate RBCs for carcinogenic effects due to exposure to chemicals the target excess lifetime cancer risk is assumed to be 10^{-6} (1 in 1 000 000) the exposure frequency is 350 days/year exposure duration is 30 years averaging time is 70 years the daily inhalation rate for airborne particulates is 20 m^3/day the soil particulate emission factor (for nonvolatile organics and inorganics) is 4 63 x 10^9 m^3/kg soil and the age adjusted soil ingestion factor is 114 mg yr/kg day

To calculate RBCs for noncarcinogens in residential soil the exposure parameters are the same as those for carcinogenic effects except the averaging time is 30 years and the target hazard quotient of 1 replaces the target excess cancer risk

All exposure parameters are EPA standard default exposure assumptions for adult residents except for the soil ingestion rates which is a time weighted average for child and adult exposures The soil ingestion intake factor takes into account the ingestion of 200 mg/day of soil by children ages 0 6 the standard default body weight for children of 15 kg the adult ingestion rate of 100 mg/day during the remaining 24 years of the 30 year exposure duration and the default adult body weight of 70 kg

RBCs for radionuclides in soil are calculated using the same intake parameters as the exposure to chemicals with the following exceptions body weight is not included in the equations the age adjusted soil ingestion factor is 3 600 mg yr/day and a gamma shielding

factor of 0 2 and a gamma exposure factor of 1 are included in the equation for external radiation exposure

4 2 RESIDENTIAL EXPOSURE TO GROUNDWATER

RBCs for residential exposure to chemicals in groundwater were calculated assuming ingestion of groundwater as drinking water and inhalation of VOCs released during domestic use To calculate RBCs for carcinogens the target excess lifetime cancer risk is 10^{-6} body weight is 70 kg averaging time is 70 years exposure frequency is 350 days/year exposure duration is 30 years daily indoor inhalation rate is 15 m^3/day the volatilization factor for VOCs is 0 5 L/m^3 and the daily ingestion rate is 2 L/day To calculate RBCs for noncarcinogenic effects all of the exposure parameters are the same except the averaging time is 30 years and the target hazard index of 1 replaces the target excess lifetime cancer risk

RBCs for radionuclides in groundwater are calculated using the same target cancer risk exposure frequency exposure duration and daily water ingestion rate used in calculating RBCs for chemical carcinogens All exposure parameters are EPA standard default exposure assumptions for adult residents

4 3 CHEMICAL-SPECIFIC RBCs

Chemical specific RBCs were calculated using the above exposure assumptions EPA chemical toxicity factors (RfDs and SFs) and a target cancer risk of 10^{-6} and hazard index of 1 The toxicity factors and RBCs are presented in DOE 1994b RBCs for PCOCs in OU2 are shown in the tables accompanying Section 5 0

5 1 RISK BASED SCREENING PROCESS

The first step in the risk based screen is to divide the maximum concentration of each PCOC in soil and groundwater in each source area by the chemical specific RBC for residential exposure to yield an RBC ratio as shown in the following equation

$$RBC\ Ratio = \frac{Maximum\ detected\ concentration}{Risk\text{-}based\ concentration}$$

The chemical specific ratios in that source area and medium are then summed to provide a ratio sum (multiple chemical) for the medium If a receptor is assumed to be exposed to more than one medium in a source area (for example hypothetical residents are assumed to be exposed to both soil and groundwater) the ratio sums for all relevant media are combined to provide a total ratio sum (multiple chemical multi media) for that exposure scenario The residential scenario assumes that excavation has taken place prior to residential development and the resident may be exposed to soil to a depth of 12 feet Therefore maximum concentrations of PCOCs in soil were identified from samples collected to a depth of 12 feet

The total ratio sums for cancer or noncancer effects are an indication of potential risks to the receptors assuming long term exposure to maximum detected concentrations of PCOCs in soil and groundwater For carcinogens a total ratio sum of less than 1 indicates a total excess lifetime cancer risk of less than 10^{-6} (1 in 1 000 000) from long term exposure to the maximum concentrations of PCOCs in that source area A total ratio sum for carcinogens that is greater than 1 but less than 100 indicates a total excess lifetime cancer risk between 10^{-4} (1 in 10 000) and 10^{-6} which is the target cancer risk range that EPA has adopted to guide remedial decisions at hazardous waste sites (40 CFR 300) Where cancer risks estimated in a baseline HHRA do not exceed 10^{-4} remediation is not generally warranted unless noncarcinogenic effects or ecological risks are significant (EPA 1991b) A total ratio sum for carcinogens that is greater than 100 indicates a potentially unacceptable cancer risk

from long term exposure to maximum detected concentrations For noncarcinogens a ratio or ratio sum less than or equal to 1 indicates no toxic effects are expected A noncarcinogenic total ratio greater than 1 indicates that there may be cause for concern for noncarcinogenic effects

This risk based screen is conservative because it assumes that a long term resident will be routinely exposed to the maximum concentrations of contaminants found in soil and groundwater The screen does not confirm that an actual risk exists Ratio sums greater than 1 or 100 indicate that the area warrants further evaluation but the ratios do not indicate that an actual health threat is present

If either the carcinogenic or noncarcinogenic total ratio sum is greater than 100 that source area may be identified by DOE as a candidate for an early action Source areas with ratio sums greater than 100 as well as those with ratio sums between 1 and 100 will be evaluated further in the baseline HHRA for OU2 If both the carcinogenic and noncarcinogenic total ratio sums are less than one the source area is a candidate for no further action based on human health risk In these cases the incremental risk from dermal exposure is evaluated to confirm that the total ratio sums including dermal exposure are still less than one

5 2 RATIO SUMS FOR SOURCE AREAS

5 2 1 903 Pad Source Area

In the 903 Pad Source Area 60 PCOCs were detected in soil to 12 feet The carcinogenic and noncarcinogenic ratio sums for soil based on residential exposure are 3 460 and 4 5 respectively (Table 5 1) Pu 239 240 Am 241 and arsenic in subsurface soil found in the surface soil are the greatest contributors to the ratio sum In groundwater 87 PCOCs were identified Both the carcinogenic ratio sum (334 000) and the noncarcinogenic ratio sum (1 280) exceed 1 (Table 5 2) based on long term residential exposure to maximum detected concentrations 1 1 Dichloroethene carbon tetrachloride chloroform cis 1 3 dichloropropene and trichloroethene are the major contributors to the carcinogenic ratio sum carbon tetrachloride chloroform and cis 1 3 dichloropropene are the major contributors to the noncarcinogenic ratio sum in groundwater

The total carcinogenic and noncarcinogenic ratio sums for the residential scenario are the sums of the ratios for soil and groundwater At the 903 Pad Source Area both the carcinogenic and noncarcinogenic total ratio sums for the hypothetical resident are greater than 100 (337 460 for carcinogens and 1 284 for noncarcinogens as shown on the summary Table 5 10)

5 2 2 Mound Source Area

At the Mound Source Area 43 PCOCs were detected in soil to 12 feet The carcinogenic ratio sum for soil is 81 1 and the noncarcinogenic ratio sum is less than 1 (Table 5 3) Pu 239 240 Am 241 Aroclor 1254 and Aroclor 1260 which are all found at their maximum concentrations in surface soil are the main contributors to the ratio sums in soil In groundwater 58 PCOCs were detected The carcinogenic ratio sum is 41 500 and the noncarcinogenic ratio sum is 83 7 (Table 5 4) based on long term residential use of groundwater containing maximum detected concentrations Vinyl chloride and tetrachloroethene are the major contributors to the carcinogenic ratio sum tetrachloroethene and antimony are the major contributors to the noncarcinogenic ratio sum in groundwater Antimony may be naturally occurring and not a result of environmental contamination

The total carcinogenic and noncarcinogenic ratio sums for the residential scenario is the sum of the ratios for soil and groundwater At the Mound Source Area both the carcinogenic and noncarcinogenic total ratio sums (41 581 and 84 respectively) exceed 1 primarily due to groundwater contaminants (see summary Table 5 10)

5 2 3 Northeast Trenches Source Area

At the Northeast Trenches Source Area 59 PCOCs were detected in soil to 12 feet The carcinogenic ratio sum for soil based on residential exposure is 1 390 and the noncarcinogenic ratio sum is 7 34 (Table 5 5) Carbon tetrachloride and tetrachloroethene are the major contributors to the carcinogenic ratio sums in soil to 12 feet In groundwater 54 PCOCs were detected The carcinogenic ratio based on residential exposure to maximum detected concentrations is 70 900 and the noncarcinogenic ratio is 363 (Table 5 6) 1 1 Dichloroethene carbon tetrachloride chloroform trichloroethene and beryllium are the major contributors to the carcinogenic ratio sum carbon tetrachloride aluminum

manganese and vanadium are the major contributors to the noncarcinogenic ratio sum in groundwater The metals in groundwater are likely to be naturally occurring and associated with elevated total suspended solids (TSS) in the groundwater samples Elevated levels of TSS can occur when there is insufficient groundwater at the monitoring well to permit adequate development prior to sampling

The total ratio sums for the residential scenario is the sum of the ratios for soil and groundwater At the Northeast Trenches Source Area both the carcinogenic and noncarcinogenic total ratios (72 290 and 370 respectively) for the hypothetical resident exposed to soil and groundwater are greater than 100 (see summary Table 5 10)

5 2 4 Southeast Trenches Source Area

At the Southeast Trenches Source Area 34 PCOCs were detected in soil to 12 feet The carcinogenic ratio sum for soil based on a residential exposure is 64 3 and the noncarcinogenic ratio sum is less than one (Table 5 7) Pu 239 240 and Am 241 in surface soil are the major contributors to the ratio sum There is no groundwater associated with the Southeast Trenches Source Area

5 2 5 East of IHSSs Source Area

At the East of IHSSs Source Area 31 PCOCs were detected in soil to 12 feet The carcinogenic and noncarcinogenic ratio sums are 95 4 and 0 3 (Table 5 8) The main contributors to the carcinogenic ratio sum are Pu 239 240 Am 241 U 235 and benzo(a)pyrene in surface soil In groundwater 30 PCOCs were detected mostly metals (20 analytes) and trace concentrations (<10 μg/L) of organics (8 analytes) The carcinogenic ratio sum is 671 and the noncarcinogenic ratio sum is 33 8 (Table 5 9)

The total ratio sums for the hypothetical residential scenario is the sum of the ratio sums for soil and groundwater At the East of IHSSs Source Area the carcinogenic total ratio sum for the hypothetical resident is 766 4 and the noncarcinogenic total ratio sum is 34 14 (Table 5 10)

Arsenic beryllium and Pu 239 240 in groundwater are the major contributors to the carcinogenic total ratio sum arsenic manganese and vanadium are the major contributors to the noncarcinogenic ratio sum for groundwater The maximum concentrations of all metal and radionuclide PCOCs except lithium and nitrate were observed in monitoring wells 41591 41691 and 286 all of which are located at Indiana Street remote from potential sources of soil and groundwater contamination near the industrialized portion of the plant Furthermore undissolved metals and radionuclides are relatively immobile and are not readily transported in groundwater Therefore the occurrences of high metals and radionuclide concentrations in wells at Indiana Street are not likely to be the result of contaminant transport from upgradient sources The elevated levels of metals and radionuclides in these groundwater samples are most likely associated with high TSS in the water samples As stated earlier high TSS can occur when insufficient water is present in the saturated zone to adequately develop the well prior to sampling Except for well 41691 which is in the Walnut Creek Drainage monitoring wells at Indiana Street are often dry Comparison of metals and radionuclide concentrations with TSS from well 41691 has shown a strong correlation For example correlation coefficients of 0 994 for manganese 0 91 for plutonium 239 240 and 0 98 for americium 241 have been calculated These coefficients are very high (close to 1) and indicate that the manganese and radionuclide activities are almost entirely due to TSS which is not evidence of contamination but rather of physical aquifer conditions and well development limitations

TABLE 5 1
ROCKY FLATS OU2
RBC SCREEN FOR THE 903 PAD SOURCE AREA
SOIL TO 12 FEET (RESIDENT)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Depth in Feet of Maximum Concentration	Residential Soil RBCs Carcinogen	Residential Soil RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Organics (mg/kg)							
1 1 1 Trichloroethane	0 13	BH4387	10				
1,2 D chloro thane	0 12	BH5487	2-4	7 04E-00		1 70E-02	
1,2 Dichloroethene	0 09	07991	3		2 47E+03		3 64E-05
2 Butanone	0 12	BH4387	7 7 9		1 65E+05		7 27E-07
4 Methyl 2 pentanon	0 011	07991	3		1 37E+04		8 03E-07
Acetone	0 81	BH5587	3		2 74E+04		2 96E-05
Carbon disulfide	0 14	BH4787	8 9		2 74E+04		5 11E-06
C rbo tet achloride	0 17	06691	6 5	4 93E+00	1 92E+02	3 45E-02	8 85E-04
Chloroethane	0 007	BH2587	0 9				
Chloroform	0 051	06691	10 5	1 05E-02	2 74E-03	4 86E-04	1 86E 05
Ethylbenzene	0 026	07991	3		2 74E+04		9 49E-07
Methylene chloride	0 026	07491	3	8 54E+01	1 65E+04	3 04E-04	1 58E 06
Tetrachloroethene	0 13	BH2587	0 9	1 23E-01	2 74E+03	1 06E-02	4 74E 05
Toluen	0 55	08791	1 8		5 49E+04		1 00E-05
Total xyle s	0 23	07991	3		5 49E+05		4 19E 07
Tri hloroethene	0 1	BH2587	0 9	5 82E-01		1 72E-03	
1 4 Dichlorobenzene	0 043	08891	8 14	2 67E+01		1 61E 03	
2 Methylnaphthalene	0 16	07991	? 8				
Acenaphthene	0 058	08891	8 14		1 65E+04		3 52E-06
Benzo(a)anthracene	0 16	SS200193	0	8 77E-01		1 82E-01	
Benzo(a)pyrene	0 25	07991	2 8	8 77E-02		2 85E+00	
B nzo(b)fluoranthe	0 24	SS200193	0	8 77E-01		2 74E-01	
Benzo(k)fluoranthene	0 069	SS200193	0	8 77E+00		7 87E-03	
B nzo c acid	0 2	SS201193	0		1 10E+06		1 82E-07
B s(2-ethylh xyl)phth lat	3 4	BH2887	0 9 3 75	4 57E-01	5 49E-03	7 44E-02	6 19E-04
Butyl benzyl phthalate	0 52	06791	8 14		5 49E+04		9 47E-06
Chrysene	0 21	07991	2 8	8 77E-01		2 39E-03	
D n butyl phthalate	1	SS200193	0		2 74E+04		3 65E 05
D n-octylphthalat	0 26	BH2587	0 9		5 49E+03		4 74E-05
Fluoranthene	0 39	SS200193	0		1 10E-04		3 55E-05
N nitrosod phenylamine	0 25	BH5487	2-4	1 31E+02		1 91E-03	
Pentachlorophenol	0 041	BH5487	2-4	5 34E+00	8 23E+03	7 68E-03	4 98E-06
Phenanthrene	0 3	07991	2 8				
Pyrene	0 57	07991	2 8		8 23E+03		6 93E 05
Pesticides/PCB (mg/kg)							
A oclo 1?54	5 9	08691	? 8	8 32E-02	1 92E-01	7 09E+01	3 07E 01
Inorganics (mg/kg)							
Arsenic	29 6	BH5487	6 ? 5	3 66E-01	8 23E+01	8 09E-01	3 60E-01
Barium	1899	BH2587	0 9		1 92E-04		9 89E 02
C dm m	5 6	BH4387	1 1 6		1 37E+02		4 09E-02
Chromium	73 1	07091	8 14		2 74E-05		2 67E 04
Cobalt	38 5	B315289	11 15				
Lead	145	PT057	0				
L thium	22 8	SS200193	0				
Mang nese	3160	46792	10 15		1 37E+03		? 31E+00
M rcury	114	BH2987	0 10		8 23E-01		1 39E+00
St ont m	45 9	SS201193	0		1 65E-05		2 78E 04

TABLE 5 1
(concluded)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Depth in Feet of Maximum Concentration	Residential Soil RBCs Carcinogen	Residential Soil RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Inorganics (cont d)							
T	38 7	SS200193	0		1 65E+05		2 35E-04
Z nc	184	09391	8 10		8 23E+04		2 24E 03
Cvanide	19 8	BH2787	0-4 8				
Nitrate	43 6	08891	2 8		4 39E+05		9 93E-05
Radionuclides (pCi/g)							
Americ um 241	160	PT029	0	2 37E+00		6 75E+01	
Cesium 137	1 6	BH2987	0 10	2 83E-01		5 65E-02	
Pluton um 239,240	11000	PT028	0	3 42E+00		3 22E+03	
Radium 226	1 6	B315289	11 14 5	2 28E+00		7 02E-01	
Radium 228	6 3?	B315289	2-4	7 93E+00		7 97E-01	
Strontium 89 90	1 58	SS200193	0	2 40E+01		6 58E-02	
Strontium 90	0 53	B315289	7 11	2 40E+01		2 21E-02	
Trit um (pCi/l)	36500	B315289	0 3	1 47E+04		2 48E+00	
Uranium 233,234	55	07591	8 14	4 47E+01		1 23E+00	
Uranium 235	2 1	07591	8 14	1 73E-01		1 21E+01	
Uranium ?38	15	07591	8 14	4 60E+01		3 26E-01	
					Ratio Sum	3 46E+03	4 50E+00

For radionuclides listed with more than one isotope the more conservativ RBC was used
Rat xceed 1 f th lyte
Rati ex eeds 100 for th s analyte

TABLE 5 2
ROCKY FLATS OU2
RBC SCREEN FOR THE 903 PAD SOURCE AREA
UHSU GROUNDWATER

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Residential Groundwater RBCs Carcinogen	Residential Groundwater RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Organics (mg/L)						
1 1 1,2 Tetrachloroethane	0 0016	06691				
1 1 1 Trichloroethane	1	07391				
1 1,2,2 Tetrachloroethane	0 18	07391	8 95E 05		2 01E+03	
1 1,2 Trichloroethane	0 021	07391	3 18E-04	1 46E-01	6 60E+01	1 44E-01
1 1 Dichloroethane	0 66	07391		1 01E+00		6 53E-01
1 1 D chloroeth	0 38	07391	1 67E 05	3 28E 01	2 28E+04	1 16E+00
1 1 Dichloropropene	0 0001	00391				
1,2 3 Trichloropropane	0 0021	06691				
1,2 Dibromoethane	0 013	07391				
1,2 Dichloroethane	0 0062	07391	1 97E-04		3 15E+01	
1,2 Dichloroethene	0 17	B218789		3 28E-01		5 18E-01
1,2 D chloropropane	0 001	06691	1 25E-03	1 11E-02	8 00E-01	9 01E-02
1 3 Dichlorobenzene	0 00017	06691				
1 3 D chloropropane	0 00026	06691				
Acetone	0 28	1187		3 65E+00		7 67E-02
Benzene	0 038	07391	6 15E 04		6 18E+01	
1,2 4 Trimethylbenzene	0 0006	07991				
1 3 5 Trimethylbenzene	0 0014	13091				
Bromobenzene	0 001	06691				
Bromochloromethane	0 71	07391				
Bromodichloromethane	0 011	2987	1 37E-03	7 30E-01	8 03E+00	1 51E-02
Bromoform	0 0064	06691	3 81E 03	7 30E-01	1 68E+00	8 77E-03
Bromomethane	0 001	1487		1 09E-02		9 17E-02
Carbon disulfide	0 0005	4189		2 76E-02		1 81E 02
Carbon tetrachloride	20	06691	2 60E-04	2 55E-02	7 69E-04	7 84E+02
Chlorobenzene	0 009	3287		5 16E-02		1 74E-01
Chloroethane	0 002	06691		2 78E+01		7 19E-05
Chloroform	39	06691	7 76E-04	3 65E-01	1 41E+05	1 07E+02
Chloromethane	0 32	06691	2 32E 03		1 38E+02	
is 1,2 D chloroethe e	1 7	08891				
c s 1 3 Dichloropropene	1 6	07391	1 27E-04	9 15E-03	1 26E+04	1 75E+02
Dibromochloromethane	0 0022	06691	1 01E-03	7 30E-01	2 18E+00	3 01E-03
D bromomethane	1 7	07391				
D hlo fl o m th	0 0045	6286				
Ethylbenzene	0 001	4186		1 58E+00		6 33E-04
Hexachlorobutadiene	0 00063	06691				
m-p Xylene	0 0003	07391				
m Xylene	0 00026	07991				
Methylene chlorid	35	06691	6 22E-03	1 73E+00	5 63E+03	2 02E+01
n Butylbenzene	0 00018	12391				
Naphthalene	0 044	12991		1 46E+00		3 01E-02
o-Chlorotoluene	0 00033	06691				
o-Xylene	0 0003	06691				

TABLE 5 2
(concluded)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Residential Groundwater RBCs Carcinogen	Residential Groundwater RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Organics (cont d)						
p-Chlorotoluene	0 0003	06691				
p-Xylene	0 0002	06691				
1,2 Dibromo-3-chloropropane	0 0042	06691				
sec Butylbenzene	0 0066	13091				
Styrene	0 001	4186		2 01E+00		4 98E-04
tert Butylbenzene	0 00041	13091				
Tetrachloroethene	14	08891	1 43E 03	3 65E-01	9 79E+03	3 84E+01
Toluene	0 11	11791		9 65E-01		1 14E-01
Total xylenes	0 002	4186		7 30E+01		2 74E 05
trans 1,2 Dichloroethene	0 034	4286				
trans 1,3 Dichloropropene	0 0081	06691	1 27E-04	9 15E-03	6 38E+01	8 85E-01
Trichloroethene	140	07391	2 55E-03		5 49E+04	
Trichlorofluoromethane	0 00057	07891				
Vinyl chloride	0 034	06691	2 81E-05		1 21E+03	
Benzo c acid	0 056	12391		1 46E+02		3 84E-04
Bis(2-ethylhexyl)phthalate	0 007	12391	6 07E-03	7 30E-01	1 15E+00	9 59E 03
Diethyl phthalate	0 31	12391		2 92E+01		1 06E-02
Inorganics (unfiltered samples) (mg/L)						
Aluminum	1460	03991				
Antimony	0 172	05191		1 46E-02		1 18E+01
Arsenic	0 0094	10991	4 86E-05	1 09E 02	1 93E+02	8 62E-01
Barium	11	03991		2 56E+00		4 30E+00
Beryllium	0 108	03991	1 98E-05	1 82E-01	5 45E+03	5 93E 01
Cadm m	0 0714	03991		1 82E-02		3 92E+00
Chromium	3 36	2987		3 65E+01		9 21E-02
Cobalt	0 627	03991				
Coppe	1 31	03991		1 46E+00		8 97E-01
Lead	0 54	03991				
Lith um	0 842	03991				
Manganese	20 2	03991		1 82E 01		1 11E+02
Mercury	0 0047	03991		1 09E 02		4 31E-01
Molybdenum	0 389	2987		1 82E-01		2 14E+00
Nickel	2 01	03991		7 30E-01		2 75E+00
Selenium	0 3	2987		1 82E-01		1 65E+00
Silver	0 0315	03991		1 82E-01		1 73E-01
Stront um	4 24	03991		2 19E+01		1 94E-01
Tin	0 642	03991		2 19E+01		2 93E-02
V d m	1 92	03991		2 56E-01		7 50E+00
Zinc	5 2	03991		1 09E+01		4 77E 01
Cyanide	0 027	07391				
Nitrate	444	08391		5 84E+01		7 60E+00
Radionu lides (unfilt red samples) (pCi/L)						
Americ um 241	46 54	09091	1 98E-01		2 35E+02	
Cesium 137	1 565	01991	1 70E+00		9 21E 01	
Plutonium 239,240	180	09091	2 07E 01		8 70E+02	
St ontium 89 90	1 2	03591	1 44E+00		8 33E-01	
				R t S m	3 34E+05	1 28E+03

For radionuclides listed with more than one sotope the more conservative RBC was used

Rat xceeds 1 fo th s a alvte

Ratio exceeds 100 for thi analyte

TABLE 5 3
ROCKY FLATS OU2
RBC SCREEN FOR THE MOUND SOURCE AREA
SOIL TO 12 FEET (RESIDENT)

Analyt	M ximum Conc ntration o A tivity	Loc tion of Maxmum Concentration	Depth in Feet of Maxmum Concentration	Residential Soil RBCs Carcinogen	Residential Soil RBCs Noncarcinogen	Ratio of Concentr tion to RBC C r in g n	Ratio of Concentr tion to RBC N n rcin g n
O ganics (mg/kg)							
1 2 D chloroethane	0 032	BH3187	12	7 04E-00		4 55E-03	
2 B tan	0 033	BH3087	11 5 17 5		1 65E+05		2 00E 07
2 Chlo thyl vinvl th	0 031	BH3087	11 5 17 5				
Ac ton	0 5	BH3487	8 14 7		2 74E+04		1 82E-05
C rbo tet a hl rid	0 015	01491	3 ‹	4 93E+00	1 92E+02	3 04E-03	7 81E-05
M thvl n hlorid	0 0374	BH3787	0 ‹	8 54E+01	1 65E+04	4 38E-04	2 27E-06
Sty ene	0 017	BH3087	11 5 17 15		5 49E+04		3 10E 07
T t achl oethen	0 02	BH3187	12	1 23E+01	2 74E+03	1 63E-03	7 30E-06
T l	0 044	02391	8 9		5 49E+04		8 01E-07
Benzo(a)anthracen	0 086	SS200293	0	8 77E-01		9 81E-02	
B nzo( )pyren	0 096	SS200293	0	8 77E-02		1 09E+00	
B nzo(b)fl oranthen	0 15	SS200293	0	8 77E-01		1 71E-01	
Benzo(gh)pervlene	0 045	SS200293	0				
Benz a d	0 25	SS200593	0		1 10E+06		2 27E-07
B s(2 thvlh xvl)phth l te	8 7	BH3787	0 5	4 57E+01	5 49E+03	1 90E-01	1 58E-03
Chrvsene	0 11	SS200093	0	8 77E+01		1 25E-03	
D butyl phth l te	3 4	BH3087	0 9		2 74E+04		1 24E 04
Fl ranthen	0 21	SS200093	0		1 10E+04		1 91E-05
I deno(1 2 3-cd)pvre	0 045	SS200293	0	8 77E-01		5 13E-02	
N nitr sod phenvlamin	0 047	BH3487	8	1 31E+02		3 59E-04	
Phenanthren	0 12	SS200593	0				
Pvrene	0 2	SS200093	0		8 23E+03		2 43E-05
P ticides/PCBs (mg/kg)							
A oclo 1254	0 97	SS200293	0	8 32E-02	1 92E+01	1 17E+01	5 05E-02
Arocl 1260	0 66	SS200293	0	8 32E-02	1 92E+01	7 93E+00	3 44E-02
Inorganics (mg/kg)							
Ars nic	15	BH3387	7 8 14 7	3 66E-01	8 23E+01	4 10E+01	1 82E 01
B ri m	140	BH3687	0 5		1 92E+04		7 29E-03
Cadmi m	3 7	BH3387	0-4		1 37E+02		2 70E-02
Chrom um	13 3	SS200593	0		2 74E+05		4 85E-05
Lead	21 7	SS200593	0				
L thium	9 6	SS200593	0				
Stront um	66 3	SS200293	0		1 65E+05		4 02E-04
T	34 3	SS200593	0		1 65E+05		2 08E-04
Zinc	75 8	SS200593	0		8 23E+04		9 21E-04
Nitr t	2 69	09891	8 2 14 2		4 39E+05		6 13E-06
R d onu lides (pCi/g)							
Ameri m 241	10 ‹5	PT032	0	2 37E+00		4 45E+00	
C m 137	2 1	BH3687	5 15	2 83E+01		7 42E-02	
Pl ton m 239 240	44 715	PT032	0	3 42E+00		1 31E+01	
Rad um 226	1 1	SS200593	0	2 28E+00		4 82E-01	
St nt um 89 90	0 443	SS200593	0	2 40E+01		1 85E-02	
Trit m (pC 1)	690	BH3287	8 15	1 47E+04		4 69E-02	
U anium 233 234	2 17	PT032	0	4 47E+01		4 85E-02	
U ani m 235	0 11	PT032	0	1 73E-01		6 36E-01	
U ani m 238	4 96	PT006	0	4 60E+01		1 08E-01	
					R to S m	8 11E+01	3 05E-01

F d l d l t d with m than o sot pe th m serv t RBC was ed
R t xce d l f th an lvt

TABLE 5-4
ROCKY FLATS OU2
RBC SCREEN FOR THE MOUND SOURCE AREA
UHSU GROUNDWATER

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Residential Groundwater RBCs		Ratio of Concentration to RBC	
			Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Organics (mg/L)						
1 1 1 2 Tetrachloroethane	0 0026	02091				
1 1 1 Trichloroethane	0 012	02291				
*1 1 2 2 Tetrachloroethane	0 0024	02091	8 95E 05		2 68E+01	
*1 1 2 Trichloroethane	0 0006	02291	3 18E 04	1 46E 01	1 89E+00	4 11E 03
1 1 Dichloroethane	0 062	3586		1 01E+00		6 14E 02
* 1 1 Dichloroethene	0 011	02291	1 67E 05	3 28E 01	6 59E+02	3 35E 02
1 2 3 Trichlorobenzene	0 00028	12091				
1 2 4 Trichlorobenzene	0 002	01391		2 34E 02		8 55E 02
*1 2 Dichloroethane	0 002	3586	1 97E 04		1 02E+01	
1 2 Dichloroethene	0 074	3586		3 28E 01		2 26E 01
1 3 Dichlorobenzene	0 002	01391				
1 4 Dichlorobenzene	0 0003	01391	3 54E 03	2 23E+00	8 47E 02	1 35E 04
2 Hexanone	0 005	3586				
4 Methyl 2 pentanone	0 001	3586		1 98E 01		5 05E 03
Benzene	0 00094	02491	6 15E 04		1 53E+00	
1 2 4 Trimethylbenzene	0 0001	12291				
1 3 5 Trimethylbenzene	0 00009	12291				
Bromochloromethane	0 00063	12091				
Carbon tetrachloride	0 003	4386	2 60E 04	2 55E 02	1 15E+01	1 18E 01
*Chloroform	0 005	02291	2 76E 04	3 65E 01	1 81E+01	1 37E 02
Chloromethane	0 00029	01891	2 32E 03		1 25E 01	
cis 1 2 Dichloroethene	0 214	02091				
Dichlorodifluoromethane	0 00019	12291				
Hexachlorobutadiene	0 00017	12091				
*Methylene chloride	0 022	01791	6 22E 03	1 73E+00	3 54E+00	1 27E 02
n Butylbenzene	0 0013	02491				
Naphthalene	0 0026	02491		1 46E+00		1 78E 03
p Cymene	0 00013	02291				
sec Butylbenzene	0 011	02491				
**Tetrachloroethene	13	02091	1 43E 03	3 65E 01	9 09E+03	3 56E+01
Toluene	0 0023	02491		9 65E 01		2 38E 03
trans 1 2 Dichloroethene	0 019	02291				
* Trichloroethene	0 41	02091	2 55E 03		1 61E+02	
Trichlorofluoromethane	0 00057	01791				
* Vinyl chloride	0 86	3586	2 81E 05		3 06E+04	
Bis(2 ethylhexyl)phthalate	0 005	12291	6 07E 03	7 30E 01	8 24E 01	6 85E 03
Di n butyl phthalate	0 003	12091		3 65E+00		8 22E 04
Inorganics (unfiltered samples) (mg/L)						
Aluminum	135	01491				
Antimony	0 236	01791		1 46E 02		1 62E+01
Arsenic	0 0072	01491	4 86E 05	1 09E 02	1 48E+02	6 61E 01
Barium	1 85	01491		2 56E+00		7 23E 01

TABLE 5 4
(concluded)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Residential Groundwater RBCs Carcinogen	Residential Groundwater RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Inorganics (cont d)						
**Beryllium	0 0153	01491	1 98E 05	1 82E 01	7 73E+02	8 41E 02
Cadmium	0 0111	01491		1 82E 02		6 10E-01
Cobalt	0 0995	01491				
Copper	0 214	01491		1 46E+00		1 47E 01
Lead	0 132	01491				
*Manganese	4 92	01791		1 82E 01		2 70E+01
Mercury	0 00062	01491		1 09E 02		5 69E 02
Nickel	0 22	01491		7 30E 01		3 01E 01
Strontium	1 11	01391		2 19E+01		5 07E 02
Vanadium	0 362	0491		2 56E 01		1 41E+00
Zinc	0 873	01491		1 09E+01		8 01E 02
Cyanide	0 011	02291				
Nitrate	8 1	02291		5 84E+01		1 39E 01
Radionuclides (unfiltered samples) (pCi/L)						
*Americium 241	1 09	12091	1 98E 01		5 51E+00	
Cesium 137	1 146	12091	1 70E+00		6 74E 01	
Plutonium 239 240[1]	0 1297	12091	2 07E 01		6 27E 01	
Strontium 89 90	0 81	01791	1 44E+00		5 63E 01	
				Ratio Sum	4 15E+04	8 37E+01

[1] For radionuclides listed with more than one isotope the more conservative RBC was used

* Ratio exceeds 1 for this analyte

** Ratio exceeds 100 for this analyte

TABLE 5-5
ROCKY FLATS OU2
RBC SCREEN FOR THE NORTHEAST TRENCHES SOURCE AREA
SOIL TO 12 FEET (RESIDENT)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Depth in Feet of Maximum Concentration	Residential Soil RBCs		Ratio of Concentration to RBC	
				Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Organics (mg/kg)							
1 1 1 Trichloroetha	13	10191	3				
1,2 Dichloroethane	0 014	BH3987	2 3 4	7 04E+00		1 99E-03	
? Butanone	0 088	BH3987	8		1 65E+05		5 33E 07
Acetone	26	10191	6 5		2 74E+04		9 49E-04
Benzene	0 012	BH4187	9 5 10 8	2 21E+01		5 43E-04	
C rbon tetrachloride	140	10191	10	4 93E+00	1 92E+02	2 84E+01	7 29E-01
Chloroform	8 8	10191	3	1 05E+02	2 74E+03	8 38E-02	3 21E-03
Methylene chloride	29	10191	8	8 54E+01	1 65E+04	3 40E-01	1 76E-03
Tetrachloroethen	13000	10191	3	1 23E+01	2 74E+03	1 06E+03	4 74E+00
Toluen	7 6	24793	8		5 49E+04		1 38E 04
Total xylenes	0 002	B217589	0 ?		5 49E+05		3 64E-09
Trichloroethene	120	10191	3	5 82E+01		2 06E+00	
2 Methylnaphthalene	8 1	10191	4 2 8				
2 Methylph nol	0 45	10291	4 2 8		1 37E+04		3 28E-05
4 Methylphenol	2 9	10191	4 2 8		1 37E+03		2 12E-03
Acenaphthene	0 28	10291	2 8		1 65E+04		1 70E-05
Anthracene	0 26	10291	2 8		8 23E+04		3 16E-06
Benzo(a)anthracene	0 53	10291	2 8	8 77E-01		6 04E-01	
Benzo(a)pyrene	0 48	10291	2 8	8 77E-02		5 47E+00	
Benzo(b)fluoranthene	0 82	10291	2 8	8 77E-01		9 35E-01	
Benzo(ghi)perylene	0 36	10291	2 8				
Benzoic acid	0 4	10291	2 8		1 10E+06		3 64E-07
B (2-ethylhexyl)phth late	5 5	10191	4 2 8	4 57E+01	5 49E+03	1 20E 01	1 00E-03
Chrysene	0 42	10291	2 8	8 77E+01		4 79E-03	
Di n butyl phthalate	1 3	10191	4 2 8		2 74E+04		4 74E-05
Fluoranthene	1	10291	2 8		1 10E+04		9 09E 05
Fluoren	0 19	10291	2 8		1 10E+04		1 73E-05
Hexachlorobutadiene	0 17	10191	8 14				
Hexachloroethane	1 1	10191	8 14	4 57E+01	2 74E+02	2 41E-02	4 01E-03
Indeno(1,2 3 cd)pyrene	0 33	10291	2 8	8 77E-01		3 76E 01	
Naphthal	2	10191	4 8		1 10E+04		1 82E-04
Phenanthr ne	2 7	10191	4 8				
Pyren	1 3	10291	2 8		8 23E+03		1 58E 04
Pesti ides/PCB (mg/kg)							
4 4 DDT	0 14	10?91	2 8	1 88E+00	1 37E+02	7 45E-02	1 02E-03
Aroclo 1?54	8 9	10?91	? 8	8 32E-02	1 92E+01	1 07E+02	4 64E-01
Inorganics (mg/kg)							
Arsen	37	BH3987	0 ?	3 66E-01	8 23E+01	1 01E+02	4 50E-01
Barium	151	10191	4 2 8		1 92E+04		7 86E-03
Cadmium	10 5	10291	2 8		1 37E+02		7 66E-02
Chromium	1?7	10291	2 8		2 74E+05		4 64E-04
Copper	132	10291	2-8		1 10E+04		1 20E 02
Lead	86 4	10191	4 2 8				
Ma gan	944	10291	8 14		1 37E+03		6 89E-01
M curv	6	10291	2 8		8 23E+01		7 29E-02
Sil e	96 5	10191	4 2 8		1 37E+03		7 04E-02
Stront um	15	PT053	0		1 65E+05		9 09E-05

TABLE 5 5
(concluded)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Depth in Feet to Maximum Concentration	Residential Soil RBCs		Ratio of Concentration to RBC	
				Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Inorg nics (ont d)							
Zinc	437	10291	2 8		8 23E+04		5 31E-03
Cyanide	4 2	10291	2 8				
Nitrate	249	10291	2 8		4 39E+05		5 67E 04
Radionuclides (pCi/g)							
Americium 241	4 154	PT053	0	2 37E−00		1 75E+00	
Ces um 137	0 16	B217589	9 13	2 83E+01		5 65E-03	
Plutonium 239.240	19 99	PT053	0	3 42E+00		5 85E+00	
Radium 226	0 8	B217589	0 3	2 28E+00		3 51E 01	
Radium 228	2 04	10491	8 14	7 93E+00		2 57E-01	
Stront um 89 90	1	BH4087	7 9	2 40E+01		4 17E 02	
Strontium 90	0 52	B217589	0 3	2 40E+01		2 17E-02	
Tritium (pCi/l)	500	B?17589	0 3	1 47E+04		3 40E-0?	
Uranium 233.234	191 7	10291	2 8	4 47E+01		4 29E+00	
Uranium 235	11 5	10291	? 8	1 73E-01		6 65E+01	
Uranium 238	113 1	10191	2 8	4 60E+01		2 46E+00	
					Ratio Sum	1 39E+03	7 34E+00

For rad onuclides listed with more than one isotope the more conservative RBC was used
Ratio exceeds 1 for th s analyte
Ratio exceeds 100 for this analyte

TABLE 5 6
ROCKY FLATS OU2
RBC SCREEN FOR THE NORTHEAST TRENCHES SOURCE AREA
UHSU GROUNDWATER

Analyte	Maximum Conc ntration or Activity	Loc tion f Maximum Conc ntr ti n	Residential Groundwater RBCs C rcinog n	Non arcinog n	Ratio of C ncentration t RBC C rcinogen	N n arcin g n
O gani (mg/L)						
1 1 1,2 Tetra hl oethan	0 00016	03791				
1 1 1 Tri hl oethan	0 13	3687				
1 1 2 2 T trachl oethan	0 00028	11691	8 95E-05		3 13E+00	
1 1 2 Tri hl oethan	0 00052	05691	3 18E-04	1 46E-01	1 64E+00	3 56E-03
1 1 D chloroethan	0 005	3687		1 01E+00		4 95E-03
1 1 D hl the	0 11	02991	1 67E-05	3 28E-01	6 59E+03	3 35E-01
1,2 3 Trichloropropane	0 00044	3687				
1 2 D hlo oethen	0 071	3687		3 28E-01		2 16E-01
4 M thyl 2 pentan	0 01	3687		1 98E-01		5 05E-02
A to	0 16	3687		3 65E+00		4 38E-02
Benzen	0 005	2587	6 15E-04		8 13E+00	
Bromochlo m than	0 00063	11891				
B om d hlo om than	0 19	3687	1 37E-03	7 30E-01	1 39E+02	2 60E-01
C rbon tet achlorid	4 5	12691	2 60E-04	2 55E-02	1 73E+04	1 76E-02
Chlorobenzene	0 016	257		5 16E-02		3 10E-01
Chloroform	0 84	3687	2 76E-04	3 65E-01	3 04E+03	2 30E+00
1 2 D hl oethen	0 3	12691				
Ethylbenzene	0 015	2587		1 58E+00		9 49E-03
M thylen chlorde	0 36	03391	6 22E-03	1 73E+00	5 79E+01	2 08E-01
Naphth l	0 085	11491		1 46E+00		5 82E 02
B tylbenz	0 23	11491				
Styren	0 014	2587		2 01E+00		6 97E-03
T t achl ro th	1	12691	1 43E-03	3 65E 01	6 99E+02	2 74E+00
Toluene	0 013	2587		9 65E-01		1 35E-02
T tal xyl ne	0 053	2587		7 30E+01		7 26E-04
tran 1 2 D hlo oethen	0 008	12191				
Trichloro then	94	3687	2 55E-03		3 69E+04	
B s(2-ethylh xyl)phth l te	0 017	12191	6 07E-03	7 30E-01	2 80E+00	2 33E-02
D thyl phthalat	0 003	11891		2 92E+01		1 03E-04
Pesti des/PCBs (mg/L)						
H pta hlo pox d	0 000065	3391	9 34E-06	4 74E-04	6 96E+00	1 37E-01
In rgani s (unfiltered amples) (mg/L)						
Al m um	886	12191				
Ant mo v	0 297	11891		1 46E-02		2 03E+01
Ar eni	0 021	05691	4 86E-05	1 09E-02	4 32E+02	1 93E+00
Bari m	11 3	12191		2 56E+00		4 41E+00
B rvll um	0 114	12191	1 98E-05	1 82E-01	5 76E+03	6 26E-01
Cadm m	0 0777	05691		1 82E-02		4 27E+00
Ch om m	0 982	12191		3 65E+01		2 69E-02
C b lt	0 651	12191				
C ppe	1 27	12191		1 46E+00		8 70E-01

TABLE 5 6
(concluded)

Analyt	Maximum C n ntr ti n or Activity	Location of M ximum Concentr tion	Residential Groundwat r RBC C r inog n	Residential Groundwat r RBC N n a cinogen	R ti f C n ntration to RBC C cin gen	R ti f C n ntration to RBC N n inog n
In ganics (cont d)						
L d	0 675	12191				
L thium	0 435	12191				
Mangane	24	12191		1 82E-01		1 32E+02
M rc ry	0 0041	05691		1 09E-02		3 76E-01
N kel	1 29	12191		7 30E-01		1 77E+00
S lver	0 057	12191		1 82E-01		3 13E-01
Stronti m	4 18	12191		2 19E+01		1 91E-01
Tin	0 342	05691		2 19E+01		1 56E-02
Vanad um	3 14	12191		2 56E-01		1 23E+01
Z	5 29	12191		1 09E+01		4 85E 01
Cyanide	0 02	03591				
N trat	10	2687		5 84E+01		1 71E-01
Radi nuclides (unfilte ed amples) (pCi/L)						
Americ um 241	0 5	11891	1 98E-01		2 53E+00	
Ce um 137	1 799	12191	1 70E+00		1 06E+00	
Pl ton m 239 240	0 8	02991	2 07E-01		3 86E+00	
				Rat o S m	7 09E+04	3 63E+02

Fo ad o cl d l ted with mo e than on sotope th more conserv t RBC was sed
Ratio xceeds 1 for th an lyte
Rat x ds 100 for th analyte

TABLE 5 7
ROCKY FLATS OU2
RBC SCREEN FOR THE SOUTHEAST TRENCHES SOURCE AREA
SOIL TO 12 FEET (RESIDENT)

Analyte	Maximum Concentration or Activity	Location of Maximum Concentration	Depth in Feet of Maximum Concentration	Residential Soil RBCs Carcinogen	Residential Soil RBCs Noncarcinogen	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC Noncarcinogen
Organics (mg/kg)							
1 1,2,2 Tetrachloroethane	0 005	08291	7 7	3 20E+00		1 56E-03	
1,2 Dichloroethane	0 008	BH4887	7	7 04E+00		1 14E 03	
2 Butanone	0 009	B319789	9 3		1 65E+05		5 45E-08
Acetone	1 7	BH5187	0 9		2 74E+04		6 20E-05
Ethylbenzene	0 004	10591	10 8		2 74E+04		1 46E-07
Methylene chloride	0 009	B319789	0 ^	8 54E+01	1 65E+04	1 05E-04	5 45E 07
T tra hloroethene	0 002	B319789	0 2	1 23E+01	2 74E+03	1 63E-04	7 30E-07
Toluene	0 48	08291	2 9		5 49E-04		8 74E-06
Total xylenes	0 014	10591	10 8		5 49E-05		2 55E-08
Bis(2-ethylhexyl)phthalate	0 066	10591	8 14	4 57E+01	2 74E+02	1 44E-03	2 41E-04
D n butyl phthalate	0 12	BH5287	0 9 5		2 74E+04		4 38E-06
N Nitrosodiph nylamine	0 052	BH5187	0 9	1 31E+02		3 97E-04	
Inorganics (mg/kg)							
Arsenic	28 4	BH5187	0 9	3 66E+01	8 23E+01	7 76E 01	3 45E-01
Barium	228	B319789	0 3		1 92E+04		1 19E-02
C dm m	5 6	BH5187	0 9		1 37E+02		4 09E-02
Chromium	29 5	SS200893	0		2 74E+05		1 08E-04
Lead	49	SS200893	0				
Lithium	22 9	SS200893	0				
Str ntium	98 3	SS200893	0		1 65E+05		5 96E-04
Tin	34 2	SS200893	0		1 65E+05		2 07E-04
Z nc	155	B218689	0 3		8 23E+04		1 88E-03
Cyanid	3 33	BH5187	0 9				
N tr te	2 6	B218689	0 3		4 39E-05		5 92E-06
Radionu lides (pCi/g)							
Americium 241	8 147	PT067	0	2 37E+00		3 44E+00	
Cesium 137	0 1	BH5387	0 18 8	2 83E+01		3 53E-03	
Plutonium 239,240	200	PT055	0	3 42E+00		5 85E+01	
Rad um 226	1 3	10691	8 14	2 28E+00		5 70E-01	
Radium 228	2 1	10691	8 14	7 93E+00		2 65E-01	
Strontium 89 90	0 34	SS200893	0	2 40E+01		1 42E 02	
Stront m 90	0 42	B319789	0 3	2 40E+01		1 75E-02	
Trit um (pCi/l)	510	08291	2 8	1 47E+04		3 47E-02	
Uranium 233,234	2 56	PT067	0	4 47E-01		5 73E 02	
U n m 235	0 1	PT055	0	1 73E-01		5 78E 01	
Uranium 238	2 58	PT067	0	4 60E-01		5 61E 02	
					Ratio Sum	6 43E+01	4 01E-01

For radio uclides l sted with more than one sotope the more conservative RBC was used
Ratio exceeds 1 for th s analyte

TABLE 5 8
ROCKY FLATS OU2
RBC SCREEN FOR THE EAST OF THE IHSSs SOURCE AREA
SOIL TO 12 FEET (RESIDENT)

Analyte	Maximum Con entr tion or Activity	Lo ation of M ximum Concentr tion	Depth in Feet t M ximum Conc ntr tion	Residential Soil RBC Ca cinogen	Residential Soil RBC Non a cinog n	Ratio of Concentration to RBC Carcinogen	Ratio of Concentration to RBC N n a inogen
O ganics (mg/kg)							
Ac ton	0 02	40591	10		2 74E+04		7 30E-07
M thylen hlond	0 003	40391	6	8 54E+01	1 65E+04	3 51E-05	1 82E-07
Toluen	0 15	40491	2 5		5 49E+04		2 73E-06
Benzo(a)anth acen	0 13	SS202893	0	8 77E-01		1 48E-01	
Benzo( )pv ene	0 14	SS202893	0	8 77E-02		1 60E+00	
B nzo(b)fl o anthe e	0 2	SS202893	0	8 77E 01		2 28E-01	
Benzo(k)fl anth	0 076	SS202893	0	8 77E+00		8 67E-03	
Benz d	0 7	SS201893	0		1 10E+06		6 36E-07
B s(2-ethvlh xvl)phthalat	0 11	SS202893	0	4 57E+01	5 49E+03	2 41E-03	2 00E-05
Chrysen	0 14	SS202893	0	8 77E+01		1 60E-03	
Fl o anthen	0 23	SS202893	0		1 10E+04		2 09E 05
Indeno(1 2 3-cd)pvr ne	0 083	SS202893	0	8 77E-01		9 46E-02	
Phenanthre	0 083	SS201393	0				
Py en	0 19	SS202893	0		8 23E+03		2 31E 05
P ti id s/PCBs (mg/kg)							
4 4 DDT	0 026	SS203293	0	1 88E+00	1 37E+02	1 38E-02	1 90E-04
d lta BHC	0 023	SS203293	0				
In rganics (mg/kg)							
A en c	25 93	41591	0 5	3 66E-01	8 23E+01	7 08E+01	3 15E 01
B ri m	390	40591	0 6		1 92E+04		2 03E 02
Ch m m	32 1	PT096	0		2 74E+05		1 17E 04
L ad	63 4	SS203593	0				
L th um	15 7	SS203693	0				
St ont m	100	SS203393	0		1 65E+05		6 06E-04
T n	93 3	SS203293	0		1 65E-05		5 65E-04
Z	77 5	SS201993	0		8 23E-04		9 42E-04
Radionuclides (pCi/g)							
Am ric m 241	5 1	PT068	0	2 37E+00		2 15E+00	
Plutonium 239 240	50 3	PT102	0	3 42E+00		1 47E+01	
Rad m 226	1 46	SS203493	0	2 28E+00		6 40E-01	
Stro t um 89 90	2 09	SS201393	0	2 40E+00		8 71E-01	
Uranium 233 234	3 4	PT068	0	4 47E+01		7 61E-02	
U anium 235	0 68	PT068	0	1 73E-01		3 93E+00	
Urani m 238	2 3	PT068	0	4 60E-01		5 00E-02	
					Rat Sum	9 54E+01	3 38E-01

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R t o ed l fo th analyt

TABLE 5 9
ROCKY FLATS OU2
RBC SCREEN FOR THE EAST OF THE IHSSs SOURCE AREA
UHSU GROUNDWATER

Analyte	M xmum C n entrati n or A tivity	Location of Maximum Con entrati n	Resid ntial Groundw te RBC C cinog n	Non cinog n	R tio of Concentration to RBC C rcinogen	Non arcinog n
Organics (mg/L)						
A t	0 01	0386		3 65E+00		2 74E 03
Chl rof rm	0 0004	06391	2 76E-04	3 65E-01	1 45E+00	1 10E-03
M thvl n chl rid	0 0033	41591	6 22E-03	1 73E+00	5 31E-01	1 91E-03
N phth len	0 0038	06391		1 46E+00		2 60E-03
T t achl oethen	0 00062	3986	1 43E-03	3 65E-01	4 34E-01	1 70E-03
Toluen	0 001	0386		9 65E-01		1 04E-03
Trichloroeth	0 0007	06291	2 55E-03		2 75E-01	
B s(2-ethvlh xyl)phth l te	0 003	41691	6 07E-03	7 30E 01	4 94E-01	4 11E 03
Inorganics (unfilt ed samples) (mg/L)						
Alum m	117	41691				
Ant monv	0 194	41691		1 46E-02		1 33E+01
Arsem	0 01	41591	4 86E-05	1 09E-02	2 06E+02	9 17E-01
B rı m	1 32	41691		2 56E+00		5 16E 01
Beryll m	0 0089	41691	1 98E-05	1 82E-01	4 49E+02	4 89E-02
Cadm m	0 0062	41691		1 82E-02		3 41E 01
Ch m m	0 248	0286		3 65E+01		6 79E-03
C b lt	0 0811	41691				
Copp	0 189	41691		1 46E+00		1 29E 01
L d	0 0966	41691				
L th m	0 248	06491				
Mangan	3 01	41691		1 82E-01		1 65E+01
Me rv	0 00072	41691		1 09E-02		6 61E-02
N k l	0 219	0286		7 30E-01		3 00E-01
S l	0 0103	41691		1 82E-01		5 66E-02
Stro t m	2 47	41591		2 19E−01		1 13E-01
Van d m	0 312	41691		2 56E-01		1 22E+00
Z	0 665	41691		1 09E+01		6 10E 02
Cvan d	0 0688	41591				
N t t	8 7	4186		5 84E+01		1 49E-01
Radionuclides (unfiltered samples) (pCi/L)						
Am rı m 241	0 4695	41691	1 98E-01		2 37E+00	
Pl to m 239 240	2 204	41691	2 07E-01		1 06E+01	
				Rat o S m	6 71E+02	3 38E+01

F r ad n l d s l t d with more than on sotope th m re on rv t RBC was sed
Rat o exceeds 1 for this analyte
R t o ex e d 100 fo th an lvt

TABLE 5 10
ROCKY FLATS OU2
SUMMARY OF TOTAL RATIO SUMS BY SOURCE AREA

	Medium	Carcinogenic Ratio	Noncarcinogenic Ratio
903 Pad	Soil to 12 feet	3460 00	4 50
	Groundwater	334000 00	1280 000
Total Ratio [1]		337460 00	1284 500
Mound	Soil to 12 feet	81 10	0 31
	Groundwater	41500 00	83 70
Total Ratio [1]		41581 10	84 01
Northeast Trenches	Soil to 12 feet	1390 00	7 34
	Groundwater	70900 00	363 00
Total Ratio [1]		72290 00	370 34
Southeast Trenches	Soil to 12 feet	64 30	0 40
East of IHSSs	Soil to 12 feet	95 40	0 34
	Groundwater	671 00	33 80
Total Ratio [1]		766 40	34 14

[1] Total Carcinogenic Ratio > 1 equivalent to > 10^{-6} cancer risk level
Total Carcinogenic Ratio > 100 equivalent to > 10^{-4} cancer risk level
Total Noncarcinogenic Ratio > 1 equivalent to Hazard Index > 1
(All assuming long term residential exposure to maximum detected concentrations)

The results of the risk based screen are compared to decision criteria to decide the appropriate course of action for each medium in each source area The decision points are as follows

- If the ratio sum ≥ 100 a voluntary corrective action (or early action) or a baseline HHRA will be performed
- If 1 < ratio sum < 100 a baseline HHRA in accordance with Risk Assessment Guidance for Superfund (EPA 1989) must be conducted
- If ratio sum ≤ 1 no further action may be required pending evaluation of ARARs potential risk from dermal exposure

The following tables show the ratio sums for all media in each of the five source areas assuming long term residential exposure to maximum detected concentrations of PCOCs

Carcinogenic Ratio Sums

	903 Pad	Mound	Northeast Trenches	Southeast Trenches	East of IHSSs
Soil to 12 feet	3 460	81	1 390	64 3	95 4
Groundwater	334 000	41 500	70 900	N/A	671

Noncarcinogenic Ratio Sums

	903 Pad	Mound	Northeast Trenches	Southeast Trenches	East of IHSSs
Soil to 12 feet	4 5	0 09	7 34	0 002	2 22
Groundwater	1 280	83 7	363		33 8

The carcinogenic ratio sums for all media in all source areas are greater than one and total ratio sums for soil plus groundwater exceed 100 in all areas except the Southeast Trenches where groundwater is not present Therefore no source area is a candidate for no further action and all source areas are evaluated further by including them in AOCs for HHRA Groundwater at the 903 Pad Mound and Northeast Trenches source areas is a candidate for early action likewise soil at the 903 Pad and Northeast Trenches areas may be considered for early action

AOCs are defined as one or several source areas that are in close proximity and can be evaluated as a unit in the HHRA AOCs are identified in order to support the HHRA in the RFI/RI Report (DOE 1993a)

The five source areas identified in OU2 are grouped to form two areas of concern The two AOCs in OU2 are defined primarily on the basis of contiguous groundwater contaminant plumes and presence of subsurface soil contamination

AOC No 1 includes the 903 Pad Source Area Mound Source Area Northeast Trenches Source Area and Southeast Trenches Source Area The 903 Pad Mound and Northeast Trenches source areas all have high maximum concentrations of chlorinated hydrocarbons in groundwater In addition the 903 Pad Mound and Northeast Trenches source areas are hydrogeologically connected therefore they form a logical area of concern for exposure and risk assessment and evaluation of potential remedial alternatives for groundwater Subsurface soil contamination is the probable source of groundwater contamination plumes in this AOC The Southeast Trenches Source Area although not a source to groundwater is included in this AOC because the trenches are in close proximity to the Northeast Trenches source areas and because it is reasonable to evaluate the soil contamination at these trenches with adjacent source areas containing trenches

AOC No 2 includes the East of IHSSs Area AOC No 2 covers a larger geographic area than AOC No 1 No IHSSs or other waste disposal areas are present in this AOC Maximum concentrations of PCOCs are generally lower in AOC No 2 than in AOC No 1 and groundwater contamination is minimal Activities of Am 241 and Pu 239 240 in surface soil are lower than in AOC No 1 because of the greater distance from the industrialized portion of the plant PCOCs in subsurface soil are probably naturally occurring (metals) or a laboratory or field contaminant (acetone methylene chloride and toluene) because no waste materials were placed in this area Therefore it is reasonable to address this low contaminant area as one area of concern

8 0
REFERENCES

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Colorado Department of Public Health and Environment U S Environmental Protection Agency U S Department of Energy (CDPHE/EPA/DOE) 1994 Presentation on the Conservative Screen Process for Identification of Source Areas and Data Aggregation for Calculation of Exposure Point Concentrations June 3 1994

Gilbert R O 1993 Letter report recommending process for comparing Rocky Flats site analytical results to background concentrations Richard Gilbert Batelle Pacific Northwest Laboratories to Beverly Ramsey Systematic Management Services Inc July 30

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U S Department of Energy (DOE) 1994b Programmatic Risk Based Preliminary Remediation Goals Rocky Flats Plant Golden Colorado Final July 1994

U S Department of Energy (DOE) 1994c Technical Memorandum No 9 Chemicals of Concern Human Health Risk Assessment 903 Pad Mound Area and East Trenches Area Operable Unit No 2 Rocky Flats Environmental Technology Site Golden Colorado Environmental Management Department Draft Final August 1994

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U S Environmental Protection Agency (EPA) 1991a Human Health Evaluation Manual Supplemental Guidance Standard Default Exposure Factors OSWER Directive 9285 6 03

U S Environmental Protection Agency (EPA) 1991b Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions OSWER Directive 9355 0 30

U S Environmental Protection Agency (EPA) 1989 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) EPA/540/1 89/002 December

ATTACHMENT 1
BACKGROUND COMPARISON SUMMARY TABLES

The following tables summarize the results of the statistical background comparison for metals and radionuclides in surface soil subsurface soil and UHSU groundwater (unfiltered samples) The background comparison is used to identify inorganic potential chemicals of concern (PCOCs) for further evaluation in assessing nature and extent of contamination and in selecting chemicals of concern for risk assessment A PCOC is a metal or radionuclide that either (1) is shown to be significantly above background levels by one or more of four statistical tests (Slippage Quantile Gehan or t test) or (2) has one or more results exceeding the 99% upper tolerance limit (UTL) of the background data PCOCs are selected on an OU wide basis pooling all analytical results for each medium sampled

The background comparison methodology is described in more detail in Gilbert (1993) and DOE (1994)

References

Gilbert R O 1993 Letter report recommending process for comparing Rocky Flats site analytical results to background concentrations Richard Gilbert Batelle Pacific Northwest Laboratories to Beverly Ramsey Systematic Management Services Inc July 30

U S Department of Energy (DOE) 1994 Technical Memorandum No 9 Chemicals of Concern Human Health Risk Assessment 903 Pad Mound Area and East Trenches Area Operable Unit No 2 Rocky Flats Environmental Technology Site Golden Colorado Environmental Management Department Draft Final August 1994

ATTACHMENT 1
TABLE LEGEND

N_B	Number of background samples
N_S	Number of site samples
DTF_B	Detection frequency in background samples
DTF_S	Detection frequency in site samples
P_SLIP	p-value Slippage test
P_QUAN	p value Quantile test
P_GEHAN	p value Gehan test
P_T_1	p value Student s t test
SIGNIFICT	Significant difference from background based on formal statistical tests? ($p \leq 0\ 05$)
UTL99	99 percent upper tolerance limit of background data at the 99 percent confidence level
NGUTL	Number of site sample results > UTL99
PCOC	Potential chemical of concern

Table AT 1
Rocky Flats OU2
Background Comparison Summary of
Surface Soil Metals
(Concentration Unit MG/KG)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC	REMARK
ALUMINUM	18	69	1 00	1 00	0 7931	0 9605	0 9996		N	21915 4	0	NO	
ANTIMONY	18	50	0 00	0 00									NO HIT
ARSENIC	18	69	1 00	1 00	1 0000	1 0000	1 0000		N	12 9	0	NO	
BARIUM	18	69	1 00	1 00	1 0000	1 0000	1 0000		N	528 0	0	NO	
BERYLLIUM	18	69	0 50	0 20	1 0000		0 9254		N	5 2	0	NO	
CADMIUM	17	69	0 35	0 14	1 0000		0 9291		N	5 0	0	NO	
CALCIUM	18	69	1 00	1 00	0 0162	0 2169	0 1852		Y	13573 3	12	YES	
CESIUM	18	51	0 50	0 02	1 0000		0 1292		N	630 8	0	NO	
CHROMIUM	18	69	1 00	1 00	0 6271	0 9906	0 9997		N	24 8	2	YES	
COBALT	18	69	1 00	1 00	1 0000	0 4574	0 4895		N	24 8	0	NO	
COPPER	18	69	1 00	1 00	0 6271	0 7033	0 5993		N	27 3	0	NO	
IRON	18	69	1 00	1 00	0 7931	0 9906	0 9990		N	28160 4	1	YES	
LEAD	18	69	1 00	1 00	0 1846	0 2169	0 4707		N	61 4	3	YES	
LITHIUM	18	44	1 00	0 91	0 0524		0 9948		N	20 0	2	NO	Not a PCOC by P J (1)
MAGNESIUM	18	69	1 00	1 00	0 7931	0 9605	0 9323		N	7011 5	1	NO	Not a PCOC by P J (1)
MANGANESE	18	69	1 00	1 00	1 0000	0 9275	0 9800		N	2253 5	0	NO	
MERCURY	18	44	0 00	0 00									NO HIT
MOLYBDENUM	18	56	0 06	0 02	0 1289		0 0508		N	40 0	0	NO	
NICKEL	18	69	1 00	0 87	0 7931	0 9605	0 9018		N	26 9	0	NO	
POTASSIUM	18	69	1 00	1 00	0 4943	0 9605	0 9919		N	5256 8	0	NO	
SELENIUM	18	69	0 72	0 28	1 0000		0 9956		N	1 4	0	NO	
SILICON	18	40	0 94	1 00	0 0401	0 0529	0 0001		Y	3559 7	0	YES	
SILVER	18	64	0 00	0 02	1 0000		0 5000		N	10 0	0	NO	
SODIUM	18	69	0 50	0 26	0 1846		0 8341		N	1108 0	0	NO	
STRONTIUM	18	56	1 00	1 00	0 5702	0 4745	0 7377		N	90 1	2	NO	Not a PCOC by P J (1)
THALLIUM	18	69	0 28	0 06	1 0000		0 6243		N	2 0	0	NO	
TIN	18	56	0 50	0 29	1 0000		0 9858		N	75 9	1	NO	Not a PCOC by P J (1)
VANADIUM	18	69	1 00	1 00	0 7931	0 4574	0 9909		N	55 6	0	NO	
ZINC	18	69	1 00	1 00	0 6271	0 8754	0 9707		N	86 7	1	NO	Not a PCOC by P J (1)

(1) Professional judgment based on log normal UTL comparison

Table AT 2
Rocky Flats OU2
Background Comparison Summary of
Surface Soil Radionuclides
(Concentration Unit pCi/G)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC	REMARK
AMERICIUM 241	15	61	1 00	1 00	0 0001	0 0187	0 0001		Y	0 060	60	YES	
CESIUM 134	0	33	0 00	0 00									NO BKGD measurement
CESIUM 137	12	40	1 00	1 00	1 0000	0 9887	0 9975		N	3 699	0	NO	
GROSS ALPHA	9	34	1 00	1 00	0 1252	0 3146	0 2954		N	42 220	4	YES	
GROSS BETA	18	40	1 00	1 00	0 1436	0 8916	0 4532		N	54 120	0	NO	
PLUTONIUM 239 240	18	72	1 00	1 00	0 0001	0 0109	0 0001		Y	0 133	72	YES	
RADIUM 226	10	40	1 00	1 00	0 0339	0 0825	0 0307		Y	1 585	0	YES	
RADIUM 228	10	13	1 00	1 00	0 3083	0 6632	0 3781		N	4 866	0	NO	
STRONTIUM 89 90	9	29	1 00	1 00	0 0050	0 0878	0 0875		Y	2 217	0	YES	
URANIUM 233 234	13	80	1 00	1 00	0 0121	0 0403	0 0965		Y	1 826	18	YES	
URANIUM 235	13	80	1 00	1 00	0 0403	0 0403	0 0305		Y	0 179	7	YES	
URANIUM 238	13	80	1 00	1 00	0 0020	0 0403	0 0135		Y	2 086	16	YES	

Table AT 3
Rocky Flats OU2
Background Comparison Summary of
Subsurface Soil Metals
(Concentration Unit MG/KG)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC	REMARK
ALUMINUM	98	300	1 00	1 00	1 0000	0 9738	0 9954	0 9923	N	45083 1	0	NO	
ANTIMONY	66	283	0 18	0 08	0 6571		0 9377		N	47 0	0	NO	
ARSENIC	99	300	0 81	0 94	1 0000	0 0002	0 0001	0 0003	Y	17 0	8	YES	
BARIUM	99	300	0 92	0 83	1 0000	0 9850	0 9966	0 9892	N	371 1	4	YES	
BERYLLIUM	99	300	0 91	0 49	1 0000	1 0000	1 0000		N	18 2	1	NO	Not a PCOC by P J (1)
CADMIUM	81	254	0 48	0 34	0 0033		0 6824		Y	2 0	40	YES	
CALCIUM	99	300	0 90	0 99	0 0414	0 0001	0 0001	0 0001	Y	53248 1	56	YES	
CESIUM	95	196	0 78	0 62	1 0000		1 0000		N	1014 9	0	NO	
CHROMIUM	99	300	1 00	0 98	1 0000	0 9993	1 0000	0 9952	N	89 1	1	YES	
COBALT	99	300	0 34	0 52	1 0000		1 0000		N	38 1	1	YES	
COPPER	99	300	0 97	0 86	0 7519	0 9033	0 9987	0 9856	N	49 0	2	YES	
IRON	99	300	1 00	1 00	1 0000	0 9927	1 0000	0 9960	N	52385 2	0	NO	
LEAD	99	300	1 00	1 00	0 4240	1 0000	1 0000	0 9994	N	31 0	3	YES	
LITHIUM	99	192	0 48	0 74	1 0000		1 0000		N	41 9	0	NO	
MAGNESIUM	99	300	0 71	0 96	1 0000	0 7803	0 6168		N	12147 1	1	NO	Not a PCOC by P J (1)
MANGANESE	99	298	1 00	1 00	1 0000	0 6504	0 8102	0 7966	N	1194 0	1	YES	
MERCURY	86	294	0 38	0 25	0 5981		1 0000		N	2 1	2	YES	
MOLYBDENUM	99	189	0 18	0 21	0 4299		1 0000		N	67 6	0	NO	
NICKEL	96	298	0 96	0 82	1 0000	1 0000	1 0000	1 0000	N	79 9	0	NO	
POTASSIUM	98	298	0 40	0 70	1 0000		0 9225		N	8362 3	0	NO	
SELENIUM	82	288	0 27	0 04	1 0000		1 0000		N	7 1	0	NO	
SILICON	0	122		0 98									NO BKGD measurement
SILVER	83	283	0 43	0 13	0 5974		1 0000		N	33 1	2	YES	
SODIUM	99	298	0 18	0 50	1 0000		0 9999		N	3680 0	0	NO	
STRONTIUM	99	295	0 43	0 77	1 0000		0 9909		N	269 9	3	NO	Not a PCOC by P J (1)
THALLIUM	75	286	0 05	0 16	1 0000		0 9268		N	20 0	0	NO	
TIN	92	194	0 23	0 21	1 0000		0 9999		N	383 7	0	NO	
VANADIUM	99	300	0 98	0 97	1 0000	0 9982	0 9999	0 9956	N	112 8	0	NO	
ZINC	98	300	1 00	1 00	1 0000	0 7934	0 8126	0 8663	N	182 9	2	YES	

(1) Professional judgement based on log normal UTL comparison

Table AT 4
Rocky Flats OU2
Background Comparison Summary of
Subsurface Soil Radionuclides
(Concentration Unit pCi/G)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC	REMARK
AMERICIUM 241	28	267	1 00	1 00	0 0001	0 0014	0 0001	0 1855	Y	0 022	83	YES	
CESIUM 137	9)	205	1 00	1 00	0 0004	0 0005	0 0661	0 0019	Y	0 129	24	YES	
GROSS ALPHA	99	248	1 00	1 00	0 0116	0 7134	0 9902	0 1091	Y	51 423	13	YES	
GROSS BETA	99	281	1 00	1 00	0 7395	0 9953	0 9999	0 9999	N	42 022	1	YES	
PLUTONIUM 239 240	99	284	1 00	1 00		0 0001	0 0001	0 0051	Y	0 025	133	YES	
RADIUM 226	83	139	1 00	1 00	0 0936	0 9974	1 0000	0 9992	N	1 420	4	YES	
RADIUM 228	83	138	1 00	1 00	0 0349	0 5850	0 9281	0 6854	Y	2 330	6	YES	
STRONTIUM 89 90	99	234	1 00	1 00	1 0000	0 2109	0 0001	0 0008	Y	1 054	2	YES	
STRONTIUM 90(1)	0	49	0 00	0 00									
TOTAL RADIOCESIUM(2)	0	0	0 00	0 00									
TRITIUM(3)	99	260	1 00	1 00	0 0050	0 6756	0 9892	0 3281	Y	503 616	13	YES	
URANIUM 233 234	99	272	1 00	1 00	0 2872	0 1702	0 8004	0 2302	N	3 441	4	YES	
URANIUM 235	99	173	1 00	1 00	0 2557	0 2749	0 0001	0 1244	Y	0 153	6	YES	
URANIUM 238	99	279	1 00	1 00	0 4010	0 7905	0 7770	0 2293	N	1 807	6	YES	

(1) No background measurement

(2) No site measeurement

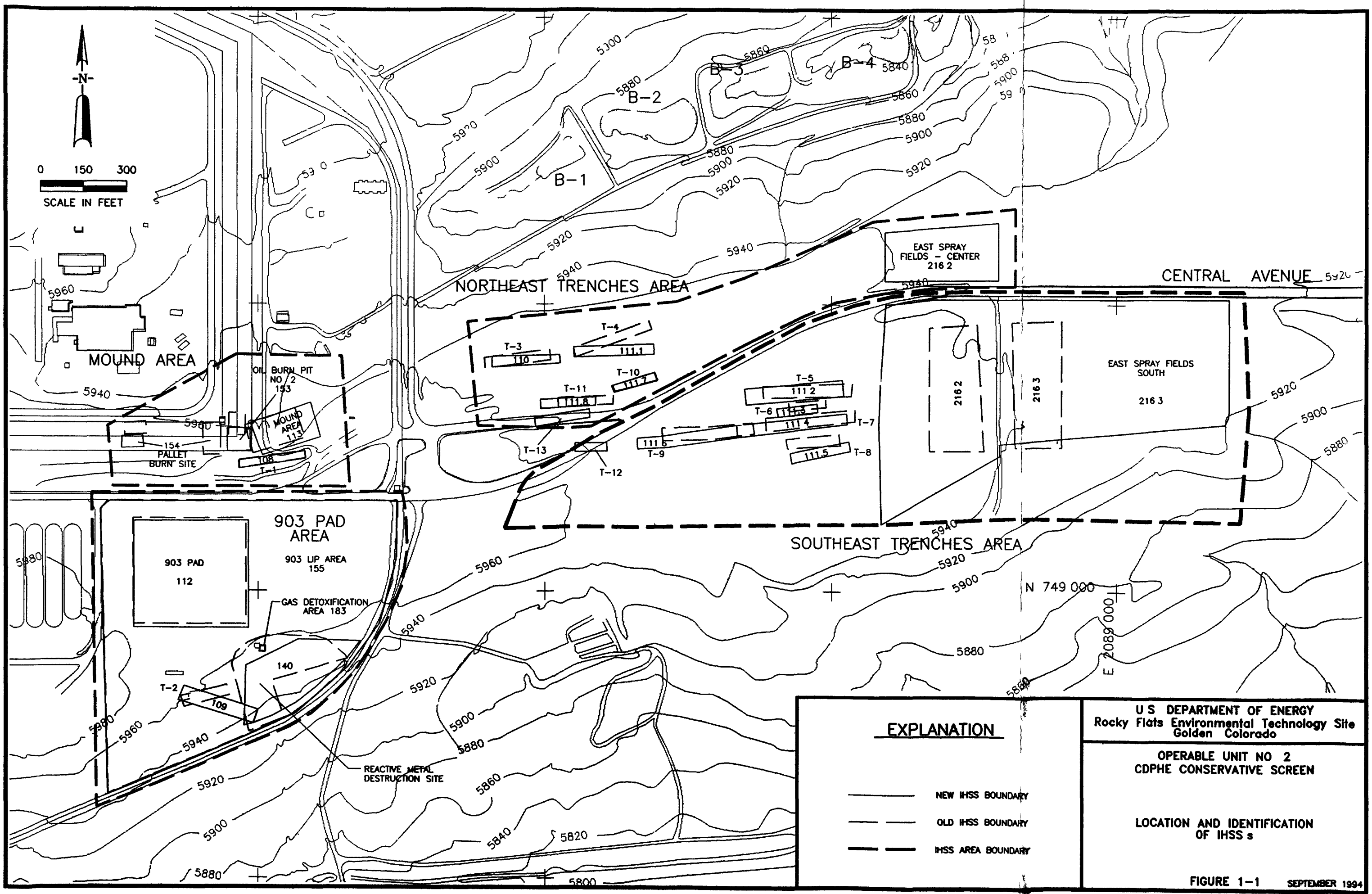
(3) Concentration Unit pCi/L

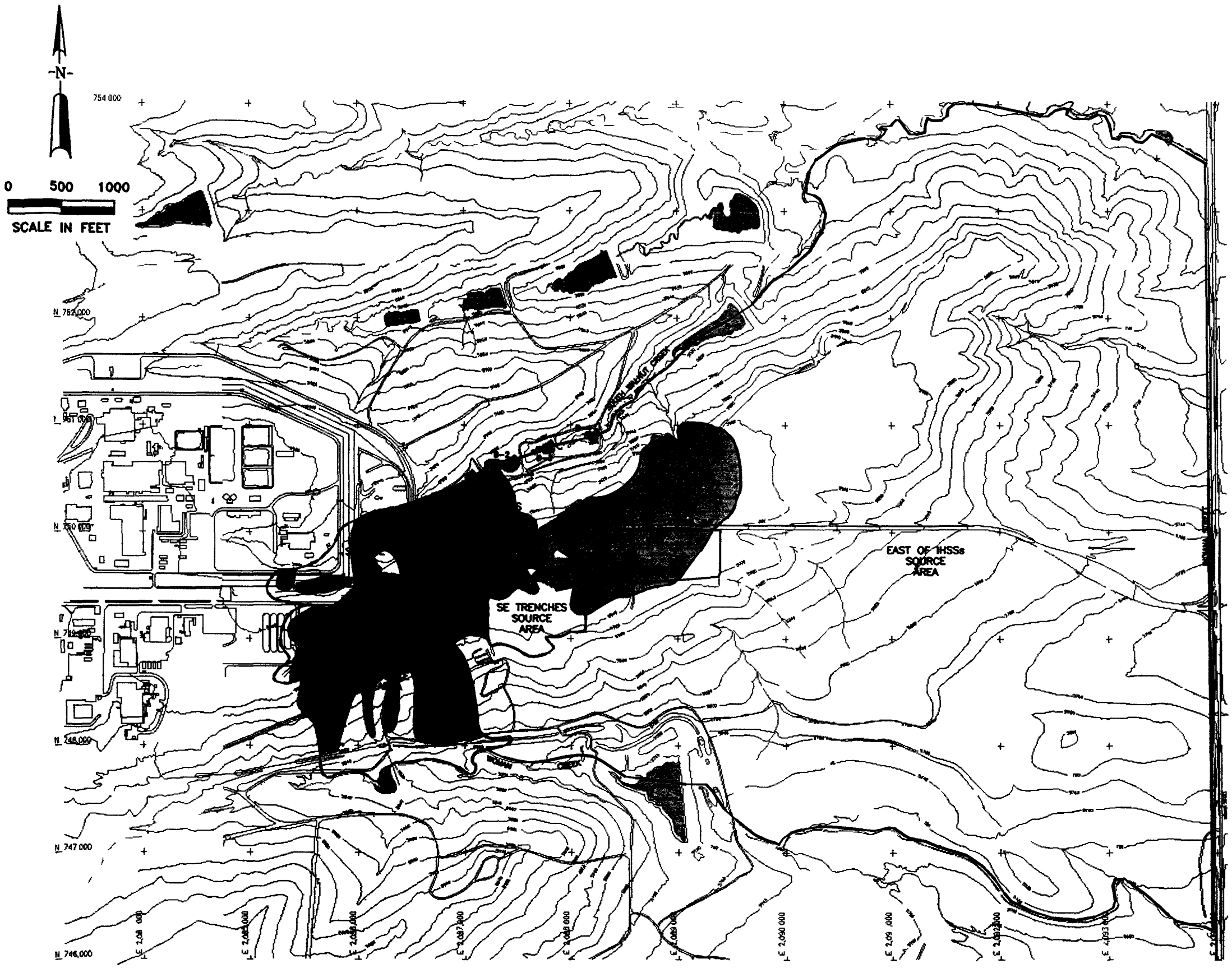
Table AT 5
Rocky Flats OU2
Background Comparison Summary of
UHSU Groundwater Unfiltered Metals
(Concentration Unit UG/L)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC REMARK
ALUMINUM	149	323	0 95	0))	0 0001	0 0001	0 0001	0 0001	Y	25624 6	75	YES
ANTIMONY	141	304	0 38	0 22	0 0211		0 0034		Y	55 8	23	YES
ARSENIC	138	296	0 28	0 60	0 0454		0 0001		Y	8 8	12	YES
BARIUM	149	323	0 74	0 94	0 0001	0 0001	0 0001		Y	300 4	138	YES
BERYLLIUM	148	318	0 12	0 43	0 0001		0 0001		Y	5 0	38	YES
CADMIUM	148	302	0 20	0 25	0 0599		0 0037		Y	11 1	7	YES
CALCIUM	149	323	1 00	1 00	0 0002	0 0001	0 0001	0 0001	Y	145353 0	51	YES
CESIUM	142	282	0 25	0 02	1 0000		0 6587		N	934 7	0	NO
CHROMIUM	145	322	0 48	0 77	0 1543	0 0001	0 0001		Y	186 4	19	YES
COBALT	148	323	0 16	0 61	0 0001		0 0001		Y	50 0	29	YES
COPPER	148	320	0 74	0 66	0 0001	0 0001	0 0001		Y	45 3	69	YES
IRON	149	323	0 98	1 00	0 0001	0 0001	0 0001	0 0001	Y	31518 5	72	YES
LEAD	141	321	0 70	0 93	0 0001	0 0001	0 0001		Y	19 3	97	YES
LITHIUM	149	322	0 77	0 86	0 2172		0 0001		Y	172 3	8	YES
MAGNESIUM	149	323	0 97	1 00	0 0001	0 0001	0 0001	0 0001	Y	33005 6	47	YES
MANGANESE	149	323	0 89	0 99	0 0001	0 0001	0 0001	0 0001	Y	626 4	91	YES
MERCURY	148	323	0 20	0 13	0 0001		0 9214		Y	0 2	38	YES
MOLYBDENUM	150	319	0 34	0 25	0 4622		0 0015		Y	195 1	2	YES
NICKEL	146	323	0 38	0 76	0 0107	0 0001	0 0001		Y	97 5	43	YES
POTASSIUM	150	323	0 71	0 91	0 0001	0 0001	0 0001		Y	5178 8	142	YES
SELENIUM	145	305	0 30	0 32	1 0000		0 3264		N	127 5	5	YES
SILICON	84	218	0 99	1 00	0 0092	0 0001	0 0001	0 0001	Y	61390 0	39	YES
SILVER	147	310	0 16	0 12	0 1421		0 8207		N	10 0	5	YES
SODIUM	149	323	0 99	1 00	0 0146	0 0032	0 0001	0 0076	Y	144226 0	19	YES
STRONTIUM	146	321	0 89	1 00	0 0015	0 0001	0 0001	0 0001	Y	1085 4	39	YES
THALLIUM	146	323	0 24	0 13	1 0000		0 4057		N	9 0	0	NO
TIN	149	304	0 35	0 15	0 3012		0 6100		N	17) 2	3	YES
VANADIUM	149	321	0 77	0 83	0 0001		0 0001		Y	68 2	69	YES
ZINC	149	323	0 91	0 96	0 0003	0 0001	0 0001	0 0001	Y	179 2	56	YES

Table AT 6
Rocky Flats OU2
Background Comparison Summary of
UHSU Groundwater Unfiltered Radionuclides
(Concentration Unit pCi/L)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUAN	GEHAN	P_T_1	SIGNIFICT	UTL99	NGUTL	PCOC	REMARK
AMERICIUM 241	183	275	1 00	1 00	0 0001	0 0001	0 0001	0 0245	Y	0 037	45	YES	
CESIUM 137	156	186	1 00	1 00	0 0862	0 0888	0 7278	0 8051	N	1 065	7	YES	
GROSS ALPHA	23	1	1 00	1 00	1 0000	1 0000	0 4142		N	390 578	0	NO	
GROSS BETA	23	1	1 00	1 00	1 0000	0 2083	0 1097		N	221 307	0	NO	
PLUTONIUM 239 240	194	293	1 00	1 00	0 0001	0 0001	0 0001	0 0268	Y	0 064	65	YES	
RADIUM 226	6	0	0 00	0 00									NO site measurement
STRONTIUM 89 90	32	14	1 00	1 00	0 3043	0 1239	0 0206		Y	1 153	1	YES	
TOTAL RADIOCESIUM	0	6	0 00	0 00									NO BKGD measurement
TRITIUM	84	407	1 00	1 00	1 0000	0 9995	0 7919	0 8482	N	12982 300	0	NO	
URANIUM 233 234	35	3	1 00	1 00	1 0000	1 0000	0 2163		N	144 836	0	NO	
URANIUM 235	35	3	1 00	1 00	1 0000	1 0000	0 7845		N	5 233	0	NO	
URANIUM 238	22	3	1 00	1 00	1 0000	1 0000	0 2516		N	114 171	0	NO	


-N-
0 150 300
SCALE IN FEET
B-1
B-2
B-3
B-4
NORTHEAST TRENCHES AREA
SOUTHEAST TRENCHES AREA
MOUND AREA
OIL BURN PIT NO 2 153
MOUND AREA 113
154 PALLET BURN SITE
108
T-1
903 PAD AREA
903 PAD 112
903 LIP AREA 155
GAS DETOXIFICATION AREA 183
REACTIVE METAL DESTRUCTION SITE
140
T-2
109
T-3 110
T-4 111.1
T-5 111.2
T-6 111.3
T-7 111.4
T-8 111.5
T-9 111.6
T-10 111.7
T-11 111.8
T-12
T-13
EAST SPRAY FIELDS - CENTER 216.2
EAST SPRAY FIELDS SOUTH 216.3
216.2
216.3
CENTRAL AVENUE
N 749 000
E 2089 000
EXPLANATION
NEW IHSS BOUNDARY
OLD IHSS BOUNDARY
IHSS AREA BOUNDARY
U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado
OPERABLE UNIT NO 2
CDPHE CONSERVATIVE SCREEN
LOCATION AND IDENTIFICATION OF IHSS s
FIGURE 1-1
SEPTEMBER 1994
CDPHE008 1=300



EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE AREAL EXTENT OF SUBSURFACE SOIL CONTAMINATION
- APPROXIMATE AREAL EXTENT OF CONTAMINATION IN THE ALLUVIAL AND COLLUVIAL UHSU FLOW SYSTEM
- APPROXIMATE AREAL EXTENT OF CONTAMINATION IN THE ARAPAHOE (NO 1) SANDSTONE UHSU FLOW SYSTEM

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Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 2
CDPHE LETTER REPORT

SOURCE AREA BOUNDARIES

FIGURE 3-1 SEPTEMBER 1994